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POUR L'EXPLORATION DE LA MER

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VOL. II · NO. 1

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E. S. RUSSELL

EN COMMISSION CHEZ
ANDR. FRED. HØST & FILS
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MARTS 1927

Note.

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IMPRIMERIE BIANCO LUNO

It is with very deep sorrow, which will be shared by every member and expert of the International Council for the Exploration of the Sea, and by many others who, though not of the Council, had relations with it, that we record the death, on March 2nd, of our friend and General Secretary Kommandør C. F. Drechsel. His death leaves a blank in the Council, in the office at Copenhagen and in our hearts, which can never be filled. From the year 1899, when he played a prominent part in the conference at Stockholm at which the idea of forming the International Council was first discussed, to within two days of his death he worked devotedly for the promotion of the objects to secure which the Council was established, and to further the best interests of the Council, its members and its experts.

We shall all miss, whenever we visit Copenhagen, his friendly greeting, his cheery personality, his thoughtful consideration for the comfort of one and all of us. But we shall treasure his memory as that of a friend and fellow-worker, who was with us heart and soul in our work and in our pastimes, and, who happily unconscious of his approaching death, was thinking of us to the end.

In the next number of Journal his career, his services to the Council, and his sterling qualities will be referred to at greater length, but we could not let this number of the Journal go forth without endeavouring briefly to express our sorrow for his loss, and the pride we feel in having been associated with him in our work.

On the Migrations of the Herring

by

A. C. Johansen.

Introduction.

The migrations of the herring constitute a problem which has occupied the attention of naturalists for some time past, albeit with no very noteworthy result. It is mainly during the last three decades that important information as to the migrations of the fish has been procured, and this information has been acquired partly by a study of the morphological peculiarities which distinguish herring developed at different places and seasons, and partly by an investigation as to the situation of the herring spawning grounds.

The high degree of interest attaching to the question of herring migrations is due partly to the great economical importance of these fish, and partly to their erratic occurrence; they are found at certain times in enormous quantities, whereas at others, they may have disappeared almost entirely from a given water. This sudden appearance and disappearance of the herring was explained, in earlier times, as due to alterations in the migrations of the fish, whereas in the last few decades, since we have learned to read the age of the herring from scales and otoliths, another explanation has been found, which is in most cases evidently correct, to wit, that the frequency of the herring in a given water depends on whether there was, or was not, some years before, a favourable survival year for the brood.

In addition to the variations observed in the annual yield of the herring fisheries, we notice particularly the variations in the yield throughout the course of the year at a given locality, and it is just these variations which must be ascribed, for by far the greater part, to peculiarities in the migrations of the fish, including their more or less pronounced tendency to collect in shoals.

In studying the migrations of the herring, we have up to now only been able to employ in a very slight degree the means used for several other fishes, namely, marking experiments. In the first place, the herring die, as we know, very soon after being taken from the water, and further, it is difficult to affix any durable mark to the fish without injury to it. The methods employed for procuring data as to the migrations of the herring have therefore been more of an indirect character.

In the first place, investigations have been made as to the morphological peculiarities in herring spawning at different times and in different places, noting the differences in shape of body, length and position of fins, number of vertebræ, keeled scales and number of rays in the ventral fins etc. etc. Furthermore, the constancy of these characters is now also studied. Among the peculiarities which have here been discerned, especial weight attaches to such characters as, once formed, remain constant throughout the whole lifetime of the individual, such as the number of vertebræ, number of fin rays and keeled scales etc. The shape of the body depends on the condition as regards nourishment and development of the sexual organs. Characters such as the shape of the cranium and the position of the ventral fins relative to the dorsal fin alter somewhat in course of development, but once the vertebræ, keeled scales and fin rays are formed, their number remains the same throughout the lifetime of the individual.

In studying the morphological peculiarities, it has been found that herring spawning in water of essentially different temperatures and salinity, also exhibit morphological difference. The herring spawning in the Baltic are of a different type from those spawning in the North Sea, and those of the North Sea again differ from those spawning on the coasts of Norway and Iceland. Furthermore, it has been found that herring spawning during the cold season of the year in a given region are of a different type from those spawning during the warmer season in the same water. There is a noticeable difference, for instance, between the spring-spawning and the summer-spawning herring of Icelandic waters, between the spring-spawning and the summer-spawning herring in the north-western part of the North Sea, and between the spring-spawning and the autumn-spawning herring in the Baltic. Even the winter-spawning and spring-spawning herring of the Kattegat differ essentially one from the other.

In addition to morphological differences proper, attention has also been devoted to the structure of scales and otoliths, number of growth zones, relative size of the nucleus, distance between the different "winter

rings" etc.[1]); and it has been suggested that a study of the distribution of individuals according to age classes may afford some indication as to which herring belong to one and the same race[2]).

Further, the position of the spawning grounds of the different races of herring has been studied, and observations made as to where the larvæ, young fish, fat herring, full herring, spent fish and recovering spents of one and the same race are to be found.

Racial investigations on a rational basis were first instituted, as regards the herring, by FRIEDRICH HEINCKE[3]) while HOFFBAUER was the first to show that the zones in the scales of certain species of fish may serve as the basis for reliable age determinations. In regard to the herring, BROCH, DAHL, LEA and others have rendered good service by their work on age determination and the closer study of the structure of the scales.

As to the location of the spawning places for the herring, T. WEMYSS FULTON, H. C. REDEKE and E. S. RUSSELL have made a good pioneer work.

The present paper deals more particularly with the horizontal migrations of the herring; I will however, also make some few remarks as to their vertical migrations.

Fishing experiments have shown that the herring larvæ do make pronounced diurnal vertical migrations, and are normally met with in far greater numbers in the upper water layers at night than during the day[4]). The same applies undoubtedly in the case of the adult fish, here due mainly to the fact that most of those pelagic organisms on which the herring feed, themselves make such diurnal migrations, and are as a rule to be found in far greater numbers in the upper water layers at night than by day. This has been shown to be the case with several different species of Copepods, Mysidæ and Euphausidæ, and several other groups of pelagic organisms[5]).

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[1]) Certain writers such as LEA, STORROW, and HODGSON have based their investigations of the herring migrations almost exclusively on a study of the scales, with appropriate calculations as to the growth of the fish.

[2]) K. A. ANDERSSON has, however, in the Skagerak and Kattegat found nearly the same distribution of year-classes in different races of autumn-spawning herrings. — Svensk Fiskeri-Tidskrift. 1916. Häft. II.

[3]) One recalls in this connection, more especially HEINCKE's accurate analyses and his numerical treatment of the variation in regard to individual characters.

[4]) A. C. JOHANSEN: On the diurnal vertical movements of young of some fishes in Danish waters. Medd. Komm. f. Havunders. Serie Fiskeri. Bd. VIII Nr. 2. 1925.

[5]) See *inter alia* F. S. RUSSELL: The Vertical Distribution of Marine Macroplankton. In Journal of Marine Biol. Assoc. Plymouth vol. XIII. No. 4, Oct. 1925.

These vertical diurnal migrations of the herring often bring them into water layers moving in different directions, thus furthering the horizontal dispersion.

As regards the horizontal migrations of the herring, distinction is naturally made between the true, active migrations and those passive migrations where the herring are carried along by the ocean currents. Among the active migrations are migrations in search of food and spawning migrations. — In actual practice, it is often impossible to demonstrate the cause of migration, even though one can show when and where it has taken place. It is often very difficult even to see which are active and which are passive migrations; we may take it that in the case of the tiny larvæ, passive migration will play a leading part, and we have proof that when the mature herring move towards the breeding grounds, they may follow a definite course, quite apart from the momentary direction of the current; in many cases, however, it has been impossible to determine whether the migrations observed were mainly of an active or of a passive character.

We will now proceed to consider some of the most important results arrived at in connection with the horizontal migrations of the herring.

Migrations of the Atlanto-Scandian Spring Herring.

The Atlanto-Scandian Spring Herring comprise two very important groups of spring-spawning herring, viz. the Icelandic spring herring and the Norwegian spring herring. With these may also be taken the Færoe spring herring, this last group however, being of but very slight importance.

We may begin with the migrations of the Icelandic spring herring. The Icelandic spring herring spawn on the south and south-western coasts of Iceland during the months of February, March and April, i. e. in the hydrographical winter season (Fig. 1). The spawning takes place in the "warm area", where the temperature is probably above 4° C.[1]) We do not know as yet at what depth their spawning grounds principally lie. As has been shown by Johs. Schmidt and P. Jespersen[2]), numbers of the pelagic herring larvæ spawned on the south and south west coasts, are carried by the current round to the western and northern Icelandic

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[1]) Johs. Schmidt: Fiskeriundersøgelser ved Island og Færøerne. København 1904.

[2]) P. Jespersen: On the occurrence of the postlarval stages of the Herring and the Lodde at Iceland and the Færoes. Medd. Komm. f. Havunders., Ser. Fiskeri. Vol. VI. No. 1, Copenhagen 1920.

waters, and even in some degree to the eastern. An essential portion of the young herring grow up in west Icelandic waters, but whether here, or on the north or east coast, they always return to the spawning grounds off the south and south-west coasts when they reach maturity.

The ripe spring herring are found on the spawning grounds of the south and south-west coasts in winter and spring. Where the spent fish mainly congregate during the months of May and June we do not

Fig. 1. Direction of resulting surface-currents and distribution of various stages of the spring spawning herring in the waters round Iceland.

know. In July, the large herring appear on the north and north-west coasts, and during July, August and September these fish form the object of an extensive fishery with drift nets and purse seine. In August and September, the large herring are also found on the east coast (Fig. 1).

On investigating samples from Kögur Huk, on the north-west coast of Iceland, and from several places off the north coast in the summer time, I found that these consisted of spring-spawning herring of the same racial type as those which spawn on the south and south-west coasts in the spring.

From the distribution of the fishing grounds it would seem as if the adult spring herring, after spawning, move for the most

part in the direction of the current (Fig. 1) as SÆMUNDSSON[1]) also supposes. Whether the movement of the spent fish immediately after spawning is of an active or passive character we do not know. During summer, the large herring feed voraciously, as shown by OVE PAULSEN[2]) on the copepod *Calanus finmarchicus*, and probably then follow the great hosts of this species. These hosts of Calanus are presumably transported mainly by the current.

The Norwegian spring herring have their spawning grounds on the west coast of Norway between Lister and Aalesund, or roughly between 58° and 63° N. Lat. (Fig. 2) and also, though to but slight extent, on the stretch between Aalesund and Sklinna Bank and on the southern coasts of Norway. Their spawning season is the same as that of the Iceland spring herring, viz: February, March and April. The temperature on the spawning grounds of the Norwegian spring herring is abt. 4—7° C., and the salinity on the main spawning grounds lies probably between abt. 33 and abt. 35 $^0/_{00}$. Quantities of the pelagic larvæ are carried northward by the current, and young and fat herring are met with in great numbers along the coast of Norway right up to the North Cape.

Where the spent fish are mainly to be found during the first few months after spawning is not known, but at a certain time, their migrations must tend in a northerly direction. The Norwegian "large herring", consisting essentially of fish which have previously spawned, are taken for the most part north of the area where the spawning grounds lie[3]). At Storeggen and north of there up towards Halten Bank, between 62° and 65° N. Lat., a very extensive large-herring fishery is carried on during the months of November and December, January and February[4]). These fish are now approaching maturity, but before spawning takes place, they must move a great distance to the southward, and, if they keep to the upper water layers, what they seem to do, they must move against the prevalent direction of the current.

In Bejstadfjord, and doubtless also in other Norwegian fjords, there exist separate races of herring, which spawn later in the year

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[1]) BJARNI SÆMUNDSSON: Oversigt over Islands Fiske. København 1908.

[2]) OVE PAULSEN: Plankton-Investigations in the waters round Iceland and in the North Atlantic in 1904. Medd. Komm. f. Havunders., Serie Plankton, Vol. I, Nr. 8. 1909.

[3]) Both spent and large maturing fish belonging to the Norwegian spring herring are found in the eastern Skagerak, but only in relatively small numbers. From the middle or southern part of the North Sea south of 57° N. Lat., the Norwegian spring herring are unknown.

[4]) THOR IVERSEN: Om en subvenert ferskfiskrute. Aarsberetning vedk. Norges Fiskerier for 1915.

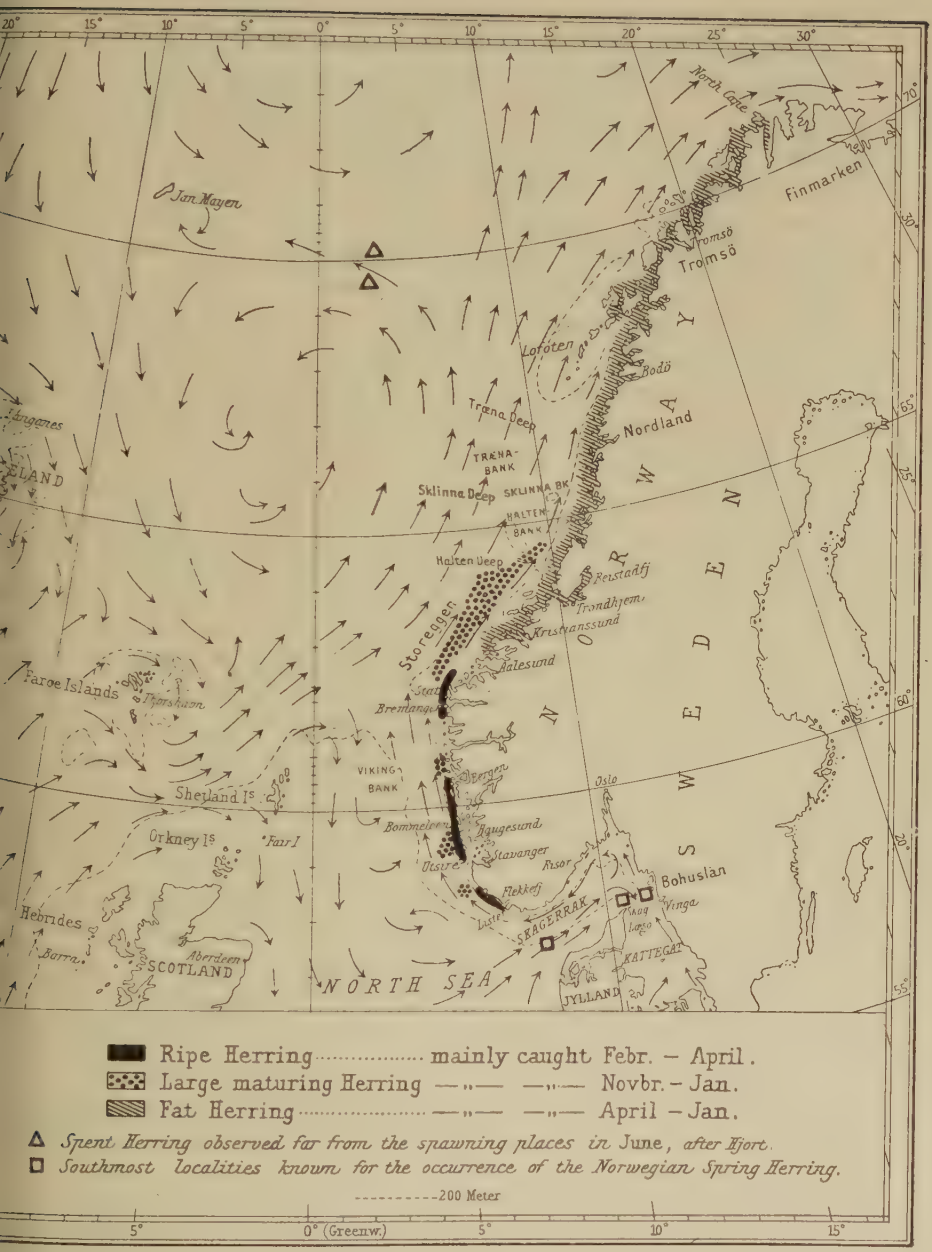

Fig. 2. Resulting surface-currents in the Norwegian Sea (after NANSEN and HELLAND-HANSEN) and main fishing places for various stages of the Norwegian spring herring (mainly after THOR IVERSEN).

than the spring herring[1]). The great bulk of the young herring and fat herring found on the coasts of Norway, however, belong to the same race as the spring herring, and it must be assumed that even the herring found on the north-western and northern coasts of Norway spawn for the most part along the range mentioned, between Skagerak and Sklinna Bank or between 58° and 65°30′ N. Lat.

Young herring are probably carried to the coasts of Norway from the Shetland Isles and the Færoes and perhaps also from Iceland, but the extent of this transport is unknown at present.

The information procured by HJORT[2]) as to the distribution of the herring in the Norwegian Sea does not by any means run counter to the supposition that the herring to a certain extent move from Iceland to Norway and vice versa. Throughout practically the whole range from the North Sea coast of Norway *via* Tangen and the Færoes to Iceland, herring have been met with in more or less considerable numbers. At the "Michael Sars" St. 2, 25 July 1900, for instance, 365 herring of 29—35 cm. length were taken by drift net at the surface; the precise locality was 63°53′ N. 7°15′ W. depth to bottom 1072 fathoms. In the course of investigations north-east of the Færoes, herring were often found in the stomachs of cod, halibut, *Macrurus* and *Molva byrkelange* taken at depths down to over 200 fathoms. This shows that the herring here have an extensive vertical range of distribution. A most interesting point is HJORT's discovery that herring occur in the Norwegian Sea midway between Norway and Jan Mayen. At 69°37′ N., 2°58′ E., 240 nautical miles from the coast, five herring of 28, 28, 29, 32 and 33 cms length were taken by drift net from the sailing cutter "Mira" on the 19th June 1901. Of these fish, the two smallest were fat herring, the three largest "blood herring". The fact that spent herring were found here proves that it is not only the young herring that undertake migrations of very great extent, but that the adult fish, after spawning, may also range very far afield. The date of capture in this case shows that the fish were spring herring. Whether they were Norwegian spring herring or Icelandic spring herring we do not know, but the nearest spawning grounds of the Norwegian spring herring lie nearer to the spot than the spawning grounds of the Icelandic spring herring.

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[1]) HJ. BROCH: Norwegische Heringsuntersuchungen während der Jahre 1904—06. Bergens Museums Aarbog 1908. No. 1.

[2]) JOHAN HJORT: Norsk Havfiske. Norges Fiskerier I. Udgivet af Selskabet for de norske Fiskeriers Fremme. Bergen 1905.

Migrations of the Summer-spawning Icelandic Herring.

The Summer-spawning Icelandic Herring spawn on the western, southern and south-eastern coasts of Iceland[1]) during the months of July and August. As shown by P. JESPERSEN[2]) the pelagic larvæ are transported by the current in the same direction as the larvæ of the spring spawning herring, i. e. westward and northward round the coast. JESPERSEN has also found large larvæ of these herring about eight months old, right round on the north-east coast in April. Whether the adult summer-spawning fish, after spawning, make similar migrations to those of the adult spring herring, moving westward and northward round the coast, has up to now remained unknown; I have however, by racial investigations[3]) during recent years, been able to demonstrate that this is the case. A sample from Kögur Huk, on the north-west coast, taken on the 6. September 1924, consisted predominantly of herring of the maturity classes VII and VIII (spent fish and recovering spents); and it was found that these fish, most of which had between 7 and 10 winter rings in the scales, were of precisely the same racial type as the summer-spawning herring that spawn on the west and south coasts.

In another herring sample from outside Eyjafjord, on the north coast, 12. Sept. 1924, there were at least as many summer-spawning as spring-spawning fish. Here also most of the summer-spawning fish were of an age which showed that they had previously spawned. As the spring herring, according to the investigations of SCHMIDT and SÆMUNDSSON, do not spawn on the north or east coasts, it is evident that the fish here in question must have moved to this locality from the west or south.

Migrations of the North Sea Bank Herring.

The North Sea Bank Herring have their main spawning grounds in the western portion of the North Sea from the Shetlands to the Southern Bight, including part of the Dogger Bank, at depths from abt. 20 to abt. 100 metres. The spawning season lasts from the beginning of July to December, and spawning takes place in water of abt. 9—14° C.

[1]) According to the information received from BJARNI SÆMUNDSSON, the summer-spawning herring of the south-east coast may spawn as far north as Reydarfjord.

[2]) P. JESPERSEN: On the occurrence of the postlarval stages of the Herring and the "Lodde" at Iceland and the Færoes. Medd. Komm. f. Havunders., Ser. Fiskeri, Vol. VI, No. 1, 1920.

[3]) A. C. JOHANSEN: Investigations on Icelandic Herrings in 1924 and 1925. Rapports et Procès-Verbaux. Conseil perm. internat., Vol. XXXIX 1926.

temperature and abt. 34—35.2 ‰ salinity[1]). The fish spawn earlier in the northern part of the area than in the southern. Off the Shetlands, and off the coast of Scotland, spawning takes place in July, August and September. Off the north-eastern coast of England mainly in August and September. On the Dogger Bank, and along the range between here and the English coast from Flamborough Head to Cromer, spawning takes place in September, October and November, and in the Southern Bight mainly in November and December.

The larvæ are carried with the currents from the middle and southern parts of the North Sea to a great extent in an easterly and north-easterly direction, and fishing experiments have shown that in winter and early spring, great masses of larvæ of autumn-spawning herring are found in the eastern part of the North Sea and in the Skagerak, though the autumn-spawning herring have normally no spawning grounds of any great importance in these waters. It has further been shown, by means of racial investigations, that the great majority of the numerous young herring found in the vicinity of the west coast of Jutland and in the southern Skagerak are of the same racial type as the bank herring of the North Sea.[1]) The young herring remain in great hosts in these waters until they are one to two years old.

Where the spent fish go to after spawning in the western part of the North Sea is still to a great extent unknown, but I have been able to ascertain, by means of racial investigations, that the "Bohuslän winter herring" caught in the eastern Skagerak (as spents or recovering spents) from December to March, are identical with the North Sea Bank Herring, while they differ from all herring races spawning in the Skagerak and Kattegat.[1])

The spent herring appear in the Skagerak at the beginning of the winter, and remain there until March at least. At the close of the fishing season, the fishery shifts over in a westerly direction. At the beginning of the season, in December and January, most of the fishing is done off the coasts of Bohuslän between Vinga and Hållö; in February and March however, the fish move farther west, off the line Skagen-Hirtshals, and in March the fishing is carried on to some extent even farther west again, outside Jammerbugt, N. W. of Rubjerg Knude. This westward movement of the fishery in early spring might seem to suggest that the fish at this season were already leaving the Skagerak and moving gradually over towards the western waters of the North Sea.

[1]) A. C. Johansen: On the Summer- and Autumn-spawning Herrings of the North Sea. Medd. Komm. for Havundersøgelser. Ser. Fiskeri, Bd. VII, Copenhagen 1924.

Fig. 3. Resulting currents in the upper layers of the North Sea and main spawning places for the North Sea Bank Herring, and fishing places for spents and recovering spents in the Skagerak.

It is certain that the Bohuslän winter herring cannot originate to any essential degree from the spawning grounds of the autumn spawning herring on the Jutland Bank and Little Fisher Bank, these grounds being, at present, of little importance. The great majority of them must come from the extensive spawning grounds in the western part of the North Sea, including the Dogger Bank.

Whether the spent herring are, to a certain extent, carried along passively with the current to the Skagerak, from the spawning grounds off the coasts of Scotland and England, or are undertaking a positive migration in search of food, is an open question. There is at any rate abundance of food for them in the Skagerak and the Norwegian Channel, e. g. *Calanus finmarchicus* and *Meganyctiphanes norvegica;* probably indeed, more food than in most parts of the North Sea. Various authors as Damas, Nybelin and Erik M. Poulsen have drawn attention to the important part played by *Meganyctiphanes* as food for the herring in the Norwegian Channel and the Skagerak. P. Jespersen has also shown that the quantity of macroplankton in the northern part of the North Sea far exceeds that in the southern and south-eastern parts, and it is natural to suppose that a great number of the spent fish would, after spawning, take up their quarters in the northern part of the North Sea in order to feed. It is characteristic that in the northern part of the North Sea, when the spawning of the Bank Herring is at an end, considerable quantities of spent fish are caught, whereas in the southwestern parts of the North Sea, between the Dogger Bank and the Southern Bight, comparatively few spents are taken.

Migrations of the Sound Herring.

The Sound Herring has its main spawning places at the southern entrance of the Sound or perhaps sometimes more southerly between Skåne, Möen and Sealand. They spawn here in September and October at depths from abt. 6 to 30 metres, where the mean salinity of the water is abt. 8—12 $^{0}/_{00}$ and the temperature abt. 12—14° C.

During the first few months after spawning, the larvæ are scattered by the currents in various directions. The northgoing surface current carry them into the Sound and the south-eastern Kattegat. The southeast-going current carries larvæ to the Arkona Basin and perhaps farther to the East (Fig. 4).

A current of Baltic water flows through the Sound out into the Kattegat (Fig. 4). South of the ridge between Dragör and Malmö, the direction

of the current is the same from surface to bottom. In the northern part of the Sound, the bottom current as a rule flows southwards, and when the surface current occasionally flows southwards, the current has the same direction from surface to bottom.

The herring fishery in the Sound takes place for the most part during the period from mid August to end October, and the herring are then taken as a rule either full or spent. The principal fishing gear used is the drift net, and the herring are taken almost exclusively in the upper water layers at less than 9 metres' depth. The nets are set out at right angles to the direction of the current, i. e. west to east, and the direction in which the fish are moving can then easily be ascertained from the manner in which they become caught in the nets. It is then found that the full herring are nearly always moving southward when captured, whether the current be flowing north or south.

The spents are mostly captured in Køge Bugt and in the waters between Stevns and Falsterbo shortly after spawning. They are there taken in the neighbourhood of the spawning grounds. The spents which are taken in the Sound, are normally caught when the current is north-going. In November the Sound Herring disappear, and during the winter the herring is but rarely caught in the Sound.

As is well known the herring fishery of the Sound was of very great importance from the XII. to the XVI. century, but it has never reached such great dimensions as the Scotch and the Norwegian herring fisheries of the present day, nor as the Bohuslän winter fishing during the great herring periods. From old data published[1]) it would seem that the yield of the herring fisheries in the Sound in the Middle ages was not very much greater than that of the present day. The entries of the customs duties for the herring have been preserved for various years of the XIV. and XV. centuries, and from these it appears that the amount of herring salted down at the two principal places of that time, viz. Skanör and Falsterbo, was as follows:

In	1368	abt.	34000	Tönder	—	probably	about	3.4	Millions Kgs.
-	1369	—	33000	—	—	—	—	3.3	— —
-	1485	—	36000	—	—	—	—	3.6	— —
-	1493	—	63000	—	—	—	—	6.3	— —
-	1494	—	51000	—	—	—	—	5.1	— —

[1]) See e. g. Dietrich Schäfer: Das Buch des Lübeckischen Vogts auf Schonen. Halle a. S. 1887, and Caspar Weinreich's: Danziger Chronik, herausgegeben von Theodor Hirsch u. F. A. Vossberg. Berlin 1855.

Fig. 4. Direction of resulting currents in the Sound and adjacent parts of the Baltic and main fishing places for the Sound Herring in August, September and Oktobe during good herring periods.

According to a report from the bailiff Franz Trebbow to King Frederik III. from 1537 the amount of herring salted down at Falsterbo was at that time about 96000 Tönder yearly, but the value of this statement is disputed[1]).

All the statements named above refer to good herring years, and the fishing towns Skanör and Falsterbo were at that time so dominating that we may assume that more than half of the herring caught in the Sound were landed at these places.

During the last good herring period from 1916 to 1920 the yield of the herring fishery in the Sound was as follows (in Millions Kilogrammes):

	Sweden (Malmöhus Län)	Denmark	Total
[1915	2.5	0.6	3.1]
1916	7.6	2.4	10.0
1917	7.5	2.4	9.9
1918	5.4	2.1	7.5
1919	3.7	3.1	6.8
1920	3.0	2.0	5.0
[1921	2.0	0.4	2.4]

The main part of the herring caught in the years 1916—21 originated from the year-class 1913. The average weight per specimen caught increased from abt. 50 grammes in 1916 to abt. 125 g. in 1920—21. It was a general opinion among the fishermen that the large herring caught in the Sound in 1920—21 came from the Skagerak or northern Kattegat, but the fish were subjected to racial investigations and they proved to be normal Sound Herrings.

The following average figures were found for herrings caught in the Sound in the years 1916—21:

Date	Locality	Average length cms	Maturity	Total No. of Vertebrae	Prec. Vertebrae	Keeled Scales K. 2	Rays in both ventral fins	No. of Specimens investig.
22— 8—1916	Off Skovshoved	20.6	IV-V	55.56	23.77	14.27	17.71	160
25—10—1916	Kallebodstrand	20.2	VII	55.59	23.95	14.20	17.81	86
12— 9—1917	Drogden	21.0	V-VI	55.58	24.02	14.38	17.73	175
8—10—1920	Drogden	24.7	V-VI-VII	55.615	23.86	14 47	17.79	234
11—10—1921	Drogden	25.3	VI-VII	55.55	23.80	14.28	17.75	200

[1]) Conf. Rudolf Lundberg: Antiquarisk Tidskrift för Sverige. XI. Stockholm 1905.

The fishing places for the Sound Herring were the same in the Middle ages and Hansa time as at present, so that there is a probability that the herring spawning places at that time were situated at the same localities where they are found to day.

During the good survival season for the Sound Herring in 1913—14 the winter was mild, as is usually the case when we have good survival years for autumn-spawners in the western and southern Baltic.

On the Causes of Secular Fluctuations in the Yield of the Bohuslän Herring Fisheries.

Apart from the fluctuations in the annual yield discernible within a short period of years, which can as a rule be traced back to good and bad survival years for the brood, it has been noticed that in several different areas fluctuations of enormous extent take place throughout longer periods, undoubtedly due to other causes. We shall now proceed to a further consideration of the secular fluctuations which have been observed in the winter herring fishery on the coasts of Bohuslän.

The statistical data bearing on the yield of the Bohuslän herring fishery in winter extend back to 1868, and, as regards the period from 1868—1918, have been tabulated by Otto Pettersson in his "Kosmiska orsaker till rörelserna uti hafvets och atmosfärens mellanskikt"[1]). A graphical illustration of the yield, with supplementary data for the years 1919—25, is reproduced in Fig. 5. In connection with this diagram however, it should be noted that the area where the fishery is carried on has during the present century been far greater than formerly. If the fishing during the present century had been continued in the form of a coast fishery, the yield for the period 1900—1925 would probably have been very small.

The most important fishing apparatus in the Bohuslän Skärgård from old times were land-seines (Swedish: landvadar). Besides these drift nets and gill nets were used, during the period here considered. According to N. Rosén[2]) the purse seine was introduced in Bohuslän in 1882, but in the beginning it played only a very subordinate rôle. At the end of the nineties of the past century, when the herring ceased to enter the Bohuslän Skärgård, the purse seine was also employed outside the Skärgård in the open sea, but it was not until motor power

[1]) Svenska Hydrografisk-Biologiska Kommissionens Skrifter, vol. VII, 1922.

[2]) N. Rosén: Det bohuslänske fiskets nuvarande laga. — Lysekil 1920.

was introduced in the fishing vessels using the purse seine that this gear came to play a very important part. This happened in 1904. During the great herring-period from 1887—1896 the Bohuslän herring fishery was still a coast fishery. After this period it became mainly a fishery

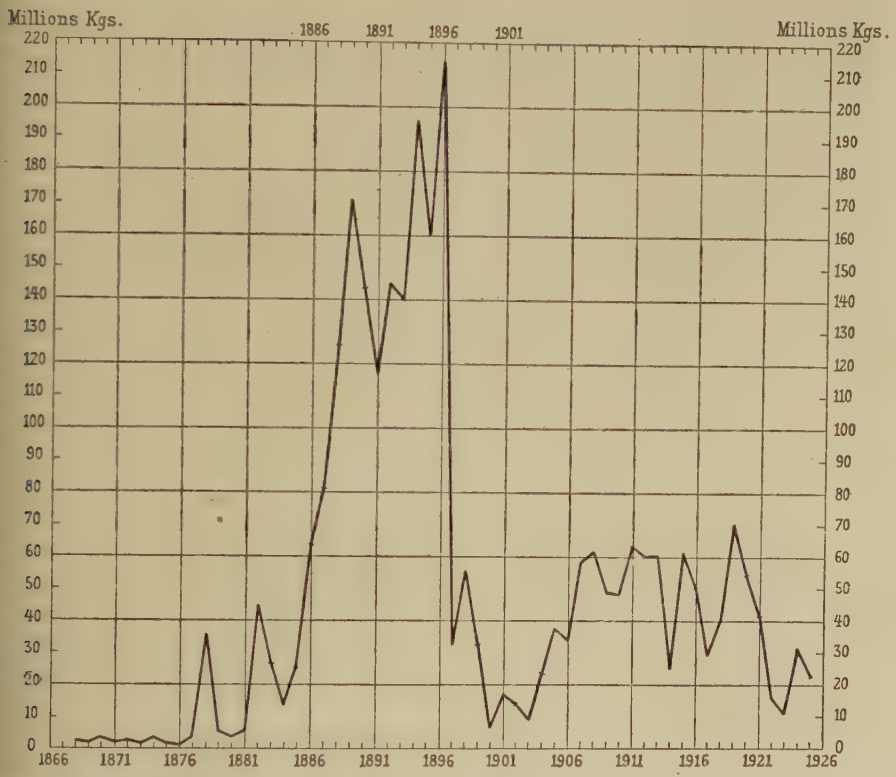

Fig. 5. Yield of the Bohuslän herring fishing in the period 1868—1925. (The yield for the season Novbr. 1867—March 1868 is put down under 1868 and so on.)

in the open sea. The purse seine soon became the main fishing gear, and also the herring trawl came in use.

The statistics for the period 1868—1925 give an idea as to the great extent of the fluctuations, and taking these in conjunction with various information as to the fishery in earlier times we gain the impression of a slow pulsation. Where the fluctuations can be traced back to good and bad survival years, we notice several maxima and minima in the course of a century. In the Bohuslän winter herring fishery, on the other hand, there seems to be a periodicity extending over more than 100 years.

According to A. V. Ljungman[1]) we can distinguish between the following periods with alternately rich and poor fishing in the coastal regions of Bohuslän:

1307—1362 very rich fishing, at least during the first third part of the century
1363—1418 no rich fishing
1419—1474 good yield, at least in the middle of the century
1475—1530 no rich fishing
1531—1586 very rich fishing, at least between 1556 and 1587
1587—1642 no rich fishing
1643—1698 good yield, at least between 1660 and 1680
1699—1747 no rich fishing
1748—1808 very rich fishing which in the last quarter of the century grew up to enormous dimensions
1809—1877 no rich fishing
(*1878—1896* very rich fishing, especially between 1887—1896 comp. Fig. 5).

Ljungman maintained that the secular periodicity in the yield corresponded with the periodicity of the solar spots, and he supposed that there was a connection between these phenomena.

Otto Pettersson, on the other hand, explains the secular periodicity in the following manner:

The secular periodicity is caused by variations in the tidal forces, which have a period of about 1800 years and maxima of lower rank of 111 years. In periods when the tidal forces are relatively strong, they cause an increment of the inflow of the northern waters into the Skagerak in autumn and winter. The inflow of water of southerly origin ("Gulff stream-water") into the Skagerak is thereby arrested during some months of the year, and supplanted by an inflow of waters from the Norwegian Sea and bankwater from the coastal banks of Norway. Thereby the spawning places of the Norwegian spring herring are removed from the west coast of Norway to the other side of the Norwegian Channel and the racial characters altered. In such periods there will be a great increase of herrings which are transported by the currents towards the East into the Skagerak. According to Pettersson the reason for the cessation of the great herring fishery in the winter of 1896 was[2]) "that

[1]) A. V. Ljungman: Bidrag till lösningen af frågan om de stora sillfiskenas sekulära periodicitet. — Nordisk Tidsskrift for Fiskeri. V. Kjøbenhavn 1879.

[2]) Otto Pettersson: Hydrography, Climate and Fisheries in the Transition Area. — Journal du Conseil, Vol. I, No. 4, Copenhague, Novembre 1926.

the waters of the Atlantic current flowed with unusual strength over the north part of the North Sea in November 1896 and the following months and filled up the Norwegian channel, so that the inflow of water from the Norwegian Sea and partly also from the north part of the North Sea to the Skagerak was checked. During the preceding herring-fishing period the inflow of "sterile" Atlantic water had been small, consequently the entrance to the Skagerak had been open to the waters of the North Sea and of the Norwegian Sea and to the herring-shoals which jointly penetrated therefrom. This meant a considerable diminution of the winter herring-fishery on the west coast of Norway, during the Swedish herring-fishing period from 1878 to 1896. Afterwards the Norwegian herring-fishery soon increased to its former importance. During the secular herring-fishing periods in the Skagerak an alternation therefore takes place between the Norwegian and the Swedish herring-fishery. This alternation has been known for two centuries, but the cause of it has only been explained by the recent hydrographical researches".

It seems to me natural to assume that Professor Pettersson is right in his view that a link in the series of causes of the secular fluctuations in the Bohuslän herring fishery must be sought in the changing quantities of oceanic water flowing into the North Sea and the Skagerak; in my opinion, however, these changes cannot have produced those biological effects upon the stock of herring which Professor Pettersson assumes. A heavy influx of water of northern origin into the Skagerak might possibly occasion an alteration in the position of the Norwegian spring herring's spawning grounds; but it could not have the effect of altering the character of the Norwegian spring herring themselves, so as to give them the same racial stamp as the autumn-spawning Bank Herring of the North Sea, and make them spawn at the same time as these[1]). To my mind, another item in the series of factors responsible for the fluctuations in the Bohuslän herring fisheries should be sought in the circumstance that a pronounced inflow of oceanic water will occasion a certain shifting of the spawning grounds of the autumn-spawning Bank Herring in the North Sea. As I have shown in my paper "On the summer- and autumn spawning herrings of the North Sea", we have important evidence to the effect that it is the North Sea Bank Herring, and not the Norwegian spring herring, which played the principal part in the Bohuslän winter fishery during the periods of rich yield.

[1]) As to the question of constancy in the races of fish, see A. C. Johansen: "On the Summer- and Autumn-spawning Herrings of the North Sea." 1924, p. 88—95.

For several years, the most important spawning grounds of the bank herring have been situated in the western part of the North Sea, including the Dogger Bank, whereas the spawning grounds on the Jutland Bank, where the salinity was abt. 0.5 ‰ lower than on the Dogger Bank and the Western spawning grounds, have been of but slight importance. During periods with marked inflow of 35 ‰ water to the Skagerak, the salinity of the Jutland Bank will rise, and from the investigations made, it is likely then that the extensive stony grounds in the vicinity of this bank would, at such times, be used for spawning to a far greater extent than in periods with slight inflow.

If the Jutland Bank affords rich spawning grounds for the North Sea Bank Herring, it is natural to suppose that great numbers of the herring, after spawning, would move in to the Skagerak in search of food, or be carried thither by the Jutland current, and also an increase of the young Bank Herring in the Skagerak would be expected in the following years.

Heincke[1]) has shown that mature Bank Herring were found on the Jutland Bank during the last great period of the Bohuslän fishery, viz. in September 1889; nothing definite was noted, however, as to the extent of the spawning.

Observations are available as to the importance of the Jutland Bank as a spawning ground for the autumn-spawning herring during 5 different years, viz. 1903, 1922, 1924, 1925 and 1926. The 1903 observations are of German origin, those for 1922—26 are Danish. The investigations are of different kinds. In the years 1903, 1924, 1925 and 1926, investigations were made as to the stomach contents of haddock taken in autumn on the Jutland Bank, and in 1922, 1925 and 1926, various fishing experiments were made with the stramin ring trawl, with a view to ascertaining the frequency of the tiny larvæ of the autumn herring.

The first-mentioned series of investigations showed that great quantities of herring roe were found in the stomachs of haddock during 1903, whereas no herring roe was found in the samples of haddock investigated from the years 1924, 1925 and 1926 (see Figs. 6 and 7). Duge[2]) describes the occurrence of herring roe in the stomachs of haddock and other fish from the area round the Jutland Bank as follows:

"During the period from 30. September to 4. October 1903, the fishing

[1]) Fr. Heincke: Naturgeschichte des Herings I, Berlin 1898.

[2]) Duge: Heringseier im Magen der Schellfische. — Mitteil. d. deutschen Seefischerei-Vereins 1903, p. 460.

steamers "Eva", Captain KULPER, and "Jade", Captain M. MODERSITZKI, of Geestemünde, were fishing on the Little Fisher Bank at abt. 57° N. Lat. and 7°0′ E. Long. where they obtained quite a good catch of large and medium haddock. When the fish were gutted, it was noticeable that the stomachs were very full, sometimes to bursting. The stomach

Fig. 6. Danish observations regarding the occurrence of herring eggs in the stomach of haddocks in the autumn of 1924.

contents consisted of small fish eggs. All the fish captured in this neighbourhood and also those found on the Jutland Bank had their stomachs filled exclusively with such eggs. Another notable feature was the great number of dead fish brought up by the nets. Apart from quite fresh fish, evidently just dead, with the eyes perfectly clear, there were others by the hundredweight which had been dead a long time. Among the dead fishes, *Lophius* were fairly common, these also having the stomachs

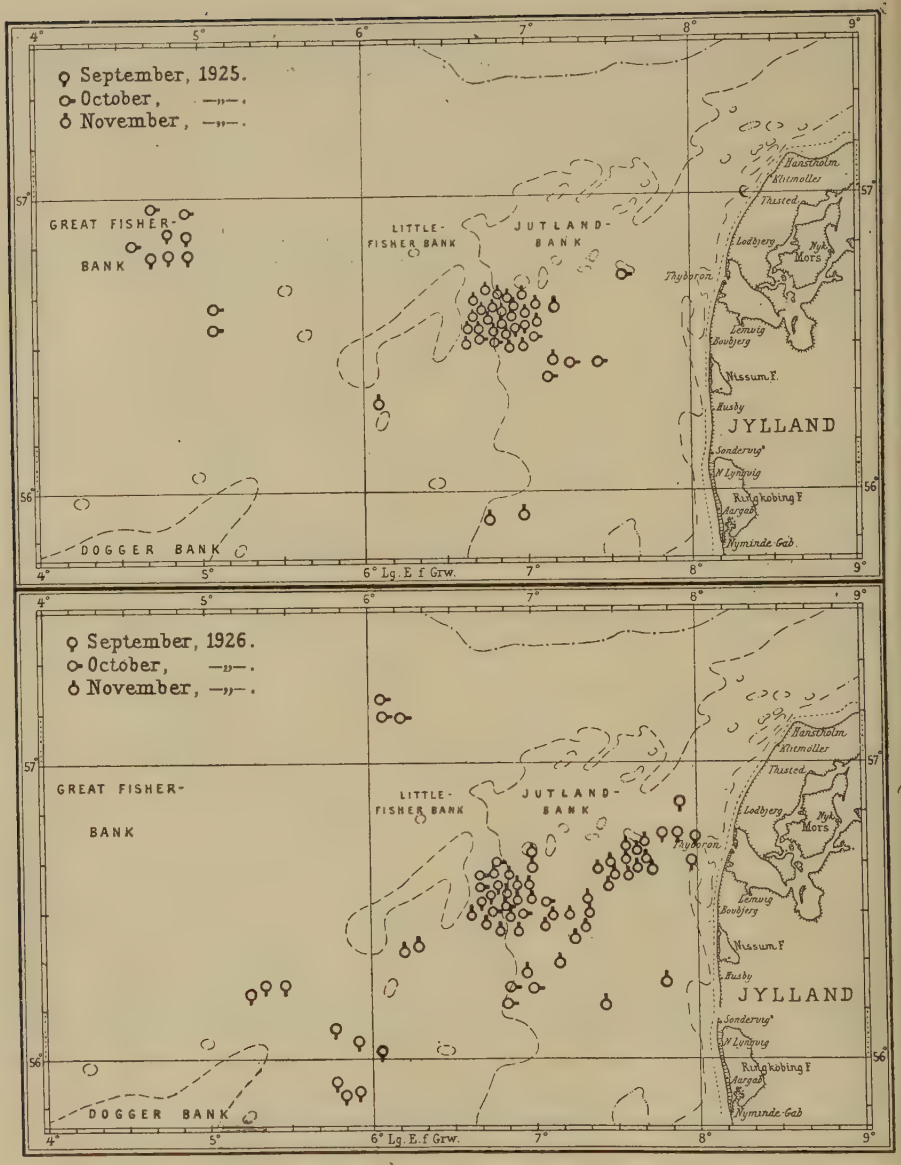

Fig. 7. Danish observations regarding the occurrence of herring eggs in the stomach of haddocks in the years 1925 and 1926 during autumn. No herring spawn was observed in this area.

full of roe. In some places, near the stony ground, great quantities of fish eggs were brought up in the nets, having become entangled in the mesh.

"The fishermen considered this phenomenon very remarkable, as there

must plainly have been altogether enormous quantities of fish eggs present on the ground, judging from the stomach contents, and the masses entangled in the nets; the men supposed that the fish had devoured such quantities of eggs that they had died of it, or, as it was declared, their stomachs had burst."

It is evident from this that the spawning of the herring in the waters round the Jutland Bank was of considerable extent in 1903, but it may have been of still greater extent during the great Bohuslän herring period in 1878–1896. However, the yield of the Bohuslän herring fishery became considerably higher in several years after 1903 than it had been in the four previous seasons[1]) (Comp. Fig. 5).

The presence of herring in considerable numbers on the Jutland Bank in the autumn of 1903 does not appear to have attracted herring fishers to the spot. And we may take it for granted that even though there may, during the great Bohuslän herring period from 1886—96, have been numbers of spawning herring on the Jutland Bank and Little Fisher Bank in the autumn, the fact was either unknown to those carrying on herring fishery in the North Sea, or the distance to the grounds was considered too great.

The results of the fishing experiments with the ring trawl in the waters round the Jutland Bank and Little Fisher Bank during the years 1922, 1925 and 1926 are shown in Fig. 8. It will be seen that during all these years, only very small quantities of herring larvæ were captured in the waters in question during the autumn.

The salinity on the Jutland Bank has probably been high in the autumn of 1903, for there was then a powerful inflow of 35 $^{0}/_{00}$ water to the intermediate layer of the Skagerak. The salinity measured at the Swedish terminal station S. Ska. 8 (58°10′ N. 10°18′ E.) at 100 metres depth was, on the 12th November 1903, 35.34 $^{0}/_{00}$. There is no indication of any similarly powerful inflow during any of the later years in which the intensity of the spawning on the Jutland Bank has been investigated. For comparison with the observations from the western portion of the Skagerak in the autumn of 1903, the following table is given, comprising corresponding observations for the years 1922 and 1925 (no observations for 1924 are available).

[1]) It is known that the winter 1903—04 was a good survival season for herring brood developed not far from the Jutland Bank. This has been shown by Dr. K. A. Andersson as regards the autumn herring of the North-eastern Kattegat (Svensk Fiskeri-Tidskrift 1916), and by Dr. Lea for the Norwegian spring herring. — When noting the increased yield of the fishery from the season 1903—04 and onwards it should also be borne in mind that the Bohuslän herring fishery in the open waters developed considerably in the years after 1904.

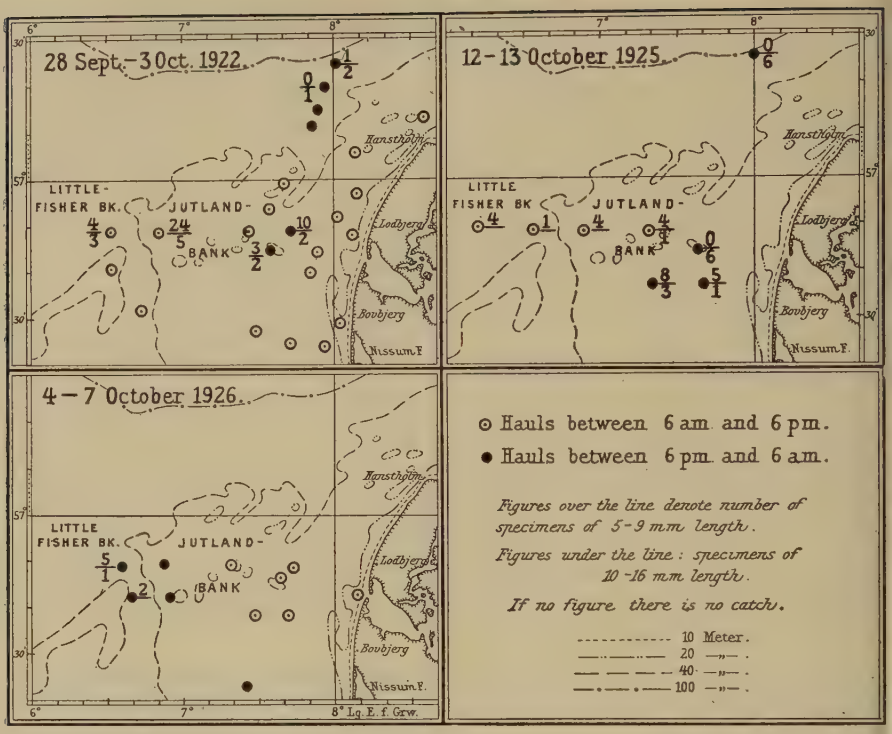

Fig. 8. Number of herring larvæ caught from the "Dana" per 30 minutes' haul with the stramin ring trawl (2 m. in diameter).

Salinity Observations from the western Skagerak in October-November

Observer	Swedish	Danish			Danish	
Year	1903	1922			1925	
Date	12 Novbr.	12 Octobr.			12 Octobr.	
N. Lat.	58°10′	58°13′	58°06′	57°54′	57°42′	57°25′
E. Long.	10°18′	9°34′	9°35′	9°34′	9°04′	8°00′
0 m	30.12	30.41	30.97	32.61	32.81	33.06
50 -	34.99	35.01	34.96	34.79	34.99	34.96
60 -	35.01	—	—	—	—	—
75 -	35.03	35.16	35.03	35.16	34.99	34.96[2])
100 -	*35.34*	35.12	35.05	35.16	35.05	—
125 -	*35.23*	—	—	—	—	—
150 -	*35.25*	—	—	—	35.07[1])	—
200 -	35.17	35.17	35.16	—	—	—

[1]) 140 m. [2]) 84 m.

The present investigations thus show clearly enough that the spawning of the herring on the Jutland Bank was of far greater extent in 1903 than in any of the subsequent years for which observations are available, viz. 1922, 1924, 1925 and 1926; and also, that in 1903, there was an unusually heavy inflow of oceanic water into the intermediate water layers of the Skagerak.

Concluding Remarks.

In the foregoing pages, a series of examples have been given, showing that we have, during the last few decades, succeeded in procuring a quantity of valuable data regarding the migrations of the herring. The present article is less concerned to show to what extent the migrations of the herring still remain mysterious. As a rule, and in the case of all the races here dealt with, the herring "disappear" for a greater or lesser portion of the year. This "disappearance" is undoubtedly often related to an extensive scattering of the fish at certain periods of their life. It is doubtless mainly the adult fish which are thus dispersed, when, as spents or recovering spents, they go hunting for food, in a more pronounced degree than otherwise. The herring seem to collect in shoals for the most part at the following stages of life:

1) as spawning fish
2) as young herring
3) as full herring — shortly before spawning
4) as spent herring — a short time after spawning has taken place.

It is at these stages the great majority of herring landed are captured. There are, however, places where also recovering spents are caught in very great numbers, as for instance on the northern coasts of Iceland in summer, and in the eastern Skagerak during winter.

In such waters, the organisms on which the herring mainly feed (e. g. *Calanus finmarchicus* and *Meganyctiphanes norvegica*) are found abundantly, in great shoals.

The investigations made indicate that every race of herring has its own particular area of migration. In the case of some races, this area is of enormous extent, while in others is it confined within narrow bounds. The Norwegian spring herring may move from the south-western coasts of Norway up to the North Cape and the Barents Sea and back again, whereas some races of herring spawning in the Kattegat and Belt Sea, never seem to leave these waters.

A Method for the Analysis and Comparison of Plankton Samples

by

Johan Hjort and **Johan T. Ruud.**

This article does not concern the collection of plankton samples nor the idea of obtaining quantitative figures for the plankton-content per unit of volume or weight of seawater or freshwater.

Hjort has previously[1]) expressed his views concerning this problem and still holds the opinion that the ideal quantitative method of investigating small plankton animals must aim at the filtration of a sample of water or of water of a known volume from a definite depth. Several experiments have been made by him in recent years in employing large water-bottles (Fig. 1) of a volume of 1 hectolitre, but such instruments had the inconvenience of catching too scanty a material, besides being very difficult to manoeuvre especially in a heavy sea.

The "water-bottles" may be improved upon by making the walls of wire-netting covered by silk net, which would make them much lighter and have the advantage of filtering the water out of the bottle before the apparatus is hauled on board. Time and circumstances have, however, not permitted experiments of this kind.[2])

It is, however, obvious that nets in any case will play a great rôle in the study of plankton for many years to come, and that it is of importance to establish a method for the treatment of material from hauls with nets, horizontal tow-nets or vertical nets. It has, as is well known, for a long time been customary to apply a rough quantitative method, employing certain signs or letters, such as r, +, ++, etc., for the frequency of the species concerned within the samples. From all sides it has been acknowledged that this method is inaccurate and

[1]) Sir John Murray and Dr. Johan Hjort: The Depths of the Ocean, Macmillan, London 1912, pag. 771 to 777.

[2]) See also the new interesting apparatus by V. J. Petterson: Svenska Hydrografisk-Biologiska Kommissionens Skrifter. Ny serie: Hydrografi. II. No. 2. 1926.

might even be quite arbitrary, but the method has nevertheless been much in use because of the general feeling that the counting of the different species would require an enormous amount of work, out of all

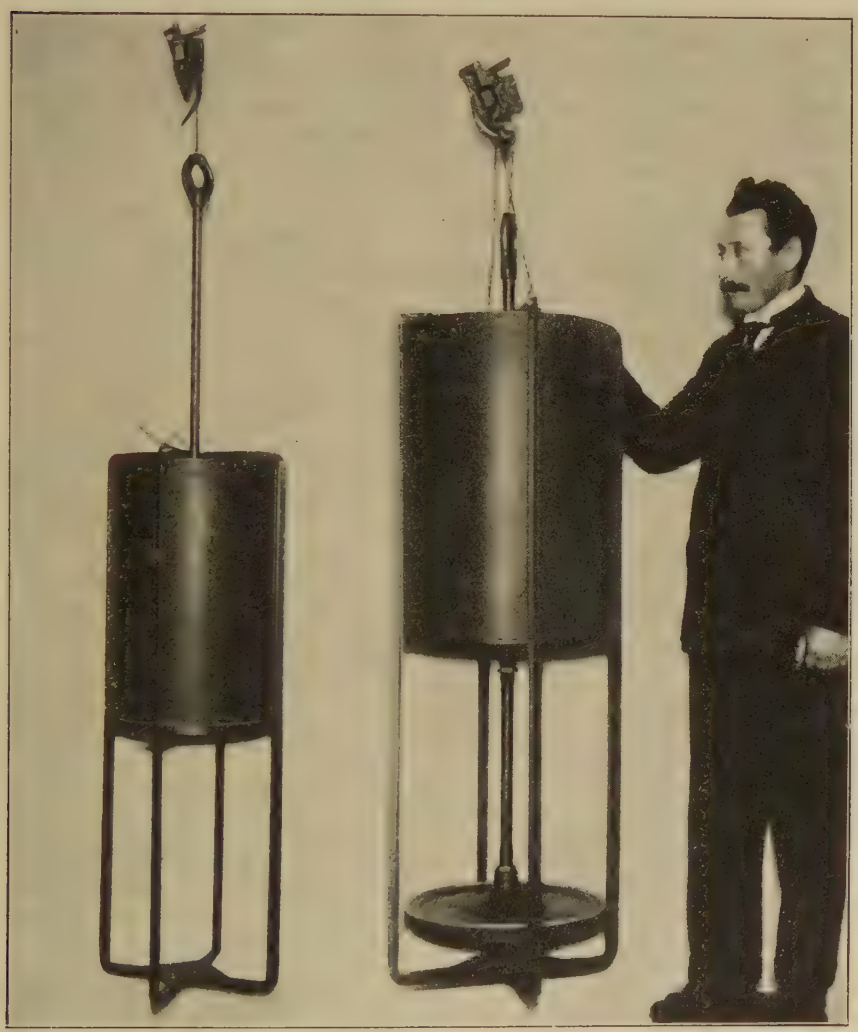

Fig. 1.

proportion to its results, because it would not really achieve the ideal, viz. the determination of the precise number of individuals per volume of water. An analysis of the samples according to Hensen's method, viz. to count the number of individuals within a known part of the known volume, has on the other hand met with practical difficulties, especially

for samples consisting of the larger Copepods. It is not very easy to disperse these animals equally through a fluid, and to take out samples of this fluid of some cubic centimeters with their contents of Copepods.

During the Canadian expedition in 1915, HJORT and ARTHUR WILLEY discussed these problems together, and as a result of these discussions WILLEY dealt with the Copepod material from the expedition in an interesting paper[1]), according to the following plan. One, two or three hundred individuals of the group of animals in which the investigator happens to be interested, are taken from the sample of plankton at random, without any selection. These individuals are determined according to species or stages of species (e. g. *Calanus finmarchicus*) and in this way a list of the percentages of the different species concerned is prepared. In this way it is possible to see the relative importance of the different species in a sample and to compare different samples with regard to their composition.

It is quite obvious that such a comparison may have a great interest, irrespective of the fact that the absolute figures (individuals per volume of water) may be unknown to the investigator. A comparison of samples collected with the same net or the same kind of net, at different localities, in different layers of water, at different times of the year, may of course give much and quite reliable information. Dr. WILLEY's paper supports this statement. The method has therefore been in practice for some years in this laboratory. The large plankton collection made by the "Michael Sars" on the expedition to the West Coast of Greenland in 1924, has been studied on these lines by Mr. LEIF STØRMER, whose paper is ready for publication, and other material collected during the years 1925 and 1926 from the Norwegian Waters off Møre has been examined by JOHAN T. RUUD in a similar way.

During this work it has, however, been the subject of discussion and experiment to improve upon the method in such a way that figures were obtained which not only gave the percentage but also the absolute numbers of individuals of certain species or stages within the sample. For this purpose the following plan has been adopted:

1) The percentages (*npc*) of the species of a certain group of animals e. g. Copepoda, or of the stages of one especially interesting species, e. g. *Calanus finmarchicus*, are determined according to the method described above.
2) By means of an analytical balance the weight of the whole sample of plankton (*W*) and of a smaller part of the same (*w*) is obtained.

[1]) The Canadian Fisheries Expedition 1914—1915. Ottawa 1919.

3) By counting all the individuals of the group concerned within the part of the sample, a figure is obtained for the number within this part (n). The number within the whole sample of plankton is then found according to the equation $N = n \frac{W}{w}$.

Table 1.

St. 68 Date $^{2}/_{6}$ 26 Hour 12^{30} V.H. 20—0 m. Vol. 14 cc No.

	npc	npc	npc
Calanus finmarchicus VI ♂	3	4	3
— — VI ♀	16	17	14
— Stage: V	52	46	50
— — IV	3	9	4
— — III	..	..	1
— — II	..	..	..
— — I	..	..	..
Calanus hyperboreus	..	..	..
Euchaeta norvegica	..	..	..
Metridia longa	..	..	..
— lucens	..	..	..
— copepodits	3	6	7
Macrocalanoids, nauplii	..	..	..
— copepodits	..	..	..
Pseudocalanus elongatus VI ♂	..	1	..
— VI ♀	2	3	2
— Stage: V	2	2	3
— — IV			
— — I—III	1	..	..
Microcalanus pusillus	7	6	6
Acartia longiremis	..	..	..
— Clausii	..	..	1
— copepodits	..	..	..
Temora longicornis	..	..	..
Microcalanoids nauplii	..	..	..
— copepodits	..	..	..
Oithona similis	6	3	4
— spinirostris	..	1	..
— copepodits	5	2	5

4) Having thus obtained the total number of all the individuals concerned within the sample, the total number of any one group, e. g. of a certain species (NS) is found by the equation $NS = npc \frac{N}{100} = npc \cdot f$.

The application of this method is very simple, and takes very little time if the species are well known to the investigator.

A sample of plankton is well shaken in the bottle, and the contents are then distributed as evenly as possible over a disc made of silk (of the same mesh as the tow-net) and a copper wire. We use discs some 17 cms. in diameter. The fluid (water, formalin, alcohol) being well filtered off the silk, the plankton is placed in a small (light) glass dish and weighed. Then a part of the sample is weighed, and the animals concerned counted under a binocular. The same discs are also used when samples are taken for the determination of the percentages of the different species.

Table 1 gives an example of three different countings of the same sample. In each case one hundred individuals were selected at random. The figures thus obtained give an illustration of the accuracy of the method. We find it quite superfluous to treat the question of accuracy by the usual statistical methods, and believe that an inspection of the Table will convey the impression that the method is sufficiently accurate for comparisons of this kind.

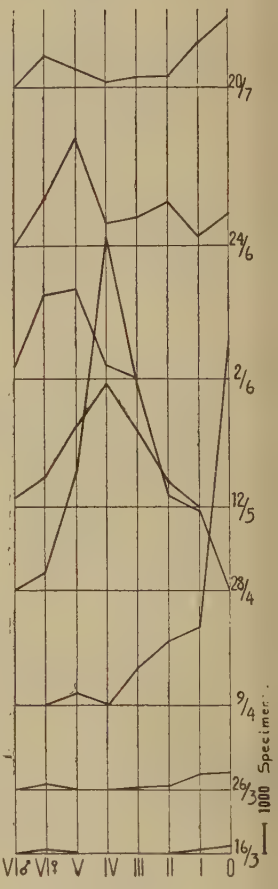

Fig. 2.

In Table No. 2 an example is given of a series of samples taken at one and the same station at different times with the same net[1]). This station (depth 80 metres) is situated on the coastal bank 17 miles off

[1]) Our net is of the construction described in the "Depths of the Ocean" page 46 fig. 29. The diameter of the net was 70 cms. The net itself consists of three parts. 1) a cylindrical net 65 cms. long of 7 mm. mesh, 2) a cylindrical part 100 cms. long ($15^1/_2$ thread per cm., mark OXX), 3) a conical part 165 cms. long ($32^1/_2$ thread per cm., mark OXXX).

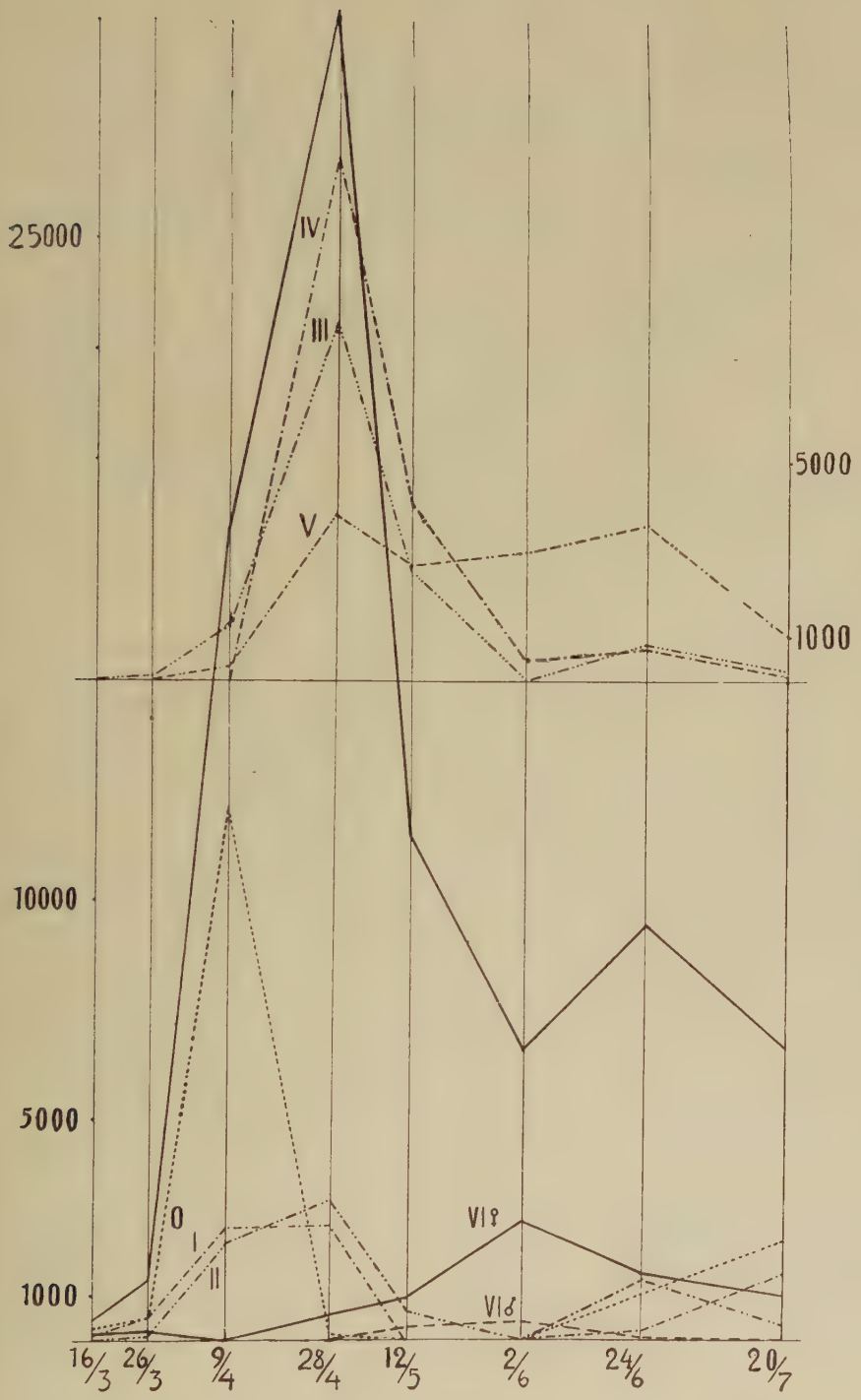
25000
5000
1000
10000
5000
1000
IV
III
V
0
I
II
VI?
VI♂
16/3
26/3
9/4
28/4
12/5
2/6
24/6
20/7

Fig. 3.

Table 2.

1926	St. 37 16/3		St. 45 26/3				St. 48 9/4				St.	
	80—0 m.		20—0		75—20		20—0		75—20		20—0	
	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS
Calanus finmarchicus VI ♂	..	..	..	..	..	..	..	..	..	..	..	..
— — VI ♀	3	137	..	..	5	229	..	..	..	..	2	58
— Stage: V	..	..	..	..	..	..	..	..	1	314	12	349
— — IV	..	..	..	..	..	..	..	..	..	..	36	1047
— — III	..	..	2	57	..	..	1	11	4	1255	21	611
— — II	..	..	3	86	..	..	1	11	7	2196	9	262
— — I	2	91	13	372	3	137	3	32	8	2510	5	145
Macrocalanoids nauplii	5	228	5	143	8	366	45	477	37	11607	..	..
Calanus hyperboreus	..	..	..	..	..	..	..	..	..	..	..	..
Euchaeta norvegica	..	..	..	..	..	..	..	..	..	..	..	..
Metridia longa	..	..	..	..	..	..	..	..	..	..	..	..
— lucens	1	46	..	..	..	..	..	..	..	..	..	..
— copepodits	..	..	..	..	..	..	..	..	..	..	..	..
Macrocalanoids copepodits	..	..	..	..	..	..	..	..	..	..	..	..
Pseudocalanus elongatus VI ♂	1	46	2	57	..	..	..	..	1	314	..	..
— — VI ♀	16	729	9	257	8	366	1	11	1	314	..	..
— Stage: IV—V	9	409	18	515	3	137	6	64	6	1882	3	87
— — I—II—III	..	..	12	343	3	137	7	74	2	628	1	29
Microcalanus pusillus	4	182	..	..	5	229	..	..	1	314	..	..
Acartia longiremis	..	..	..	..	..	..	..	..	..	..	..	..
— Clausii	1	46	1	29	..	..	1	11	..	..	2	58
— copepodits	..	..	8	229	17	778	4	42	..	..	1	29
Temora longicornis	2	91	2	57	..	..	2	21	..	..	..	..
Scolecithricella minor	..	..	..	..	..	..	..	..	..	..	..	..
Centropages { hamatus / typicus }	..	..	..	..	..	..	..	..	..	..	..	..
Microcalanoids nauplii	22	1002	4	114	5	229	17	180	31	9725	..	..
— copepodits	21	957	14	400	..	..	..	..	..	..	..	..
Oithona similis	9	409	7	200	43	1969	7	74	1	314	5	145
— spinirostris	..	..	..	..	..	..	..	..	..	..	..	..
— copepodits	4	182	..	..	..	..	5	53	..	..	3	87
Weight (whole sample)	0,638		0,451		0,601		0,776		3,808		14,635	
Weight (part of sample)	0,022		0,030		0,040		0,060		0,133		0,259	
Number (part of sample)	157		190		305		82		1096		515	
Number (whole sample)	4553		2857		4582		1060		31370		29110	
Factor	45,53		28,57		45,82		10,6		313,7		291,1	
Volume cc	1,5		1,5		2,0		2,5		11,0		48,0	

Table 2.

t. 62 $^{12}/_{6}$			St. 68 $^{2}/_{6}$				St. 80 $^{24}/_{6}$				St. 87 $^{20}/_{7}$			
	75—20		20—0		75—20		20—0		75—20		20—0		75—20	
s	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS	npc	NS
.	3	296	4	195	4	250	1	61	..	..	..	..	..	..
93	4	394	17	828	32	2003	17	1035	5	499	1	506	4	519
51	7	690	46	2238	16	1001	14	852	27	2696	..	..	8	1038
90	18	1775	9	438	2	125	4	243	5	499	..	..	1	130
72	13	1282	..	..	..	..	4	243	6	599	..	..	2	260
24	3	296	..	..	..	..	5	304	11	1098	..	..	3	389
.	..	..	..	..	..	..	2	122	1	100	3	1517	..	..
.	..	..	..	..	..	..	18	1096	..	..	4	2023	2	260
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	2	122	2	200	..	..	..	..
.	3	296	6	292	10	626	..	..	..	..	..	..	1	130
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
.	4	394	1	49	..	..	..	..	..	..	1	506	..	..
85	6	592	3	146	19	1189	..	..	4	399	..	..	4	519
69	8	789	2	97	4	250	1	61	8	798	28	14157	26	3375
.	4	394	..	..	1	63	1	61	3	299	..	..	..	..
85	6	592	6	292	3	187	..	..	10	998	..	..	2	260
.	..	..	..	..	..	..	..	..	2	200	..	..	..	..
69	..	..	..	..	..	..	1	61	..	..	7	3540	1	130
.	1	99	..	..	..	..	2	122	1	100	12	6067	4	519
.	..	..	..	..	..	..	1	61	..	..	1	506	5	649
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	1	506	1	130
.	..	..	..	..	..	..	2	122	..	..	..	..	..	..
.	..	..	..	..	..	..	..	..	..	..	..	..	..	..
38	4	394	3	146	..	..	16	974	1	100	30	15168	5	649
.	4	394	1	49	5	313	1	61	2	200	1	506	6	779
06	12	1183	2	97	4	250	8	486	12	1198	11	5562	25	3245
	3,392		5,463		6,932		4,116		7,819		2,181		4,390	
	0,160		0,202		0,155		0,165		0,271		0,096		0,165	
	465		180		140		244		346		2225		488	
	9860		4867		6261		6085		9984		50560		12980	
	98,6		48,67		62,61		60,85		99,84		505,6		129,8	
	12,5		14,0		19,0		11,5		22,0		10,0		14,0	

the coast of Møre. Table No. 2 gives the figures for the percentages (*npc*) of different species of Copepods, and, so far as the species *Calanus finmarchicus* is concerned, also for the different stages (according to the well-known proposal by D. Damas[1]). Then the total numbers of these species (*NS*) the figures for *W*, *w*, the factor *f* and the volume of the sample.

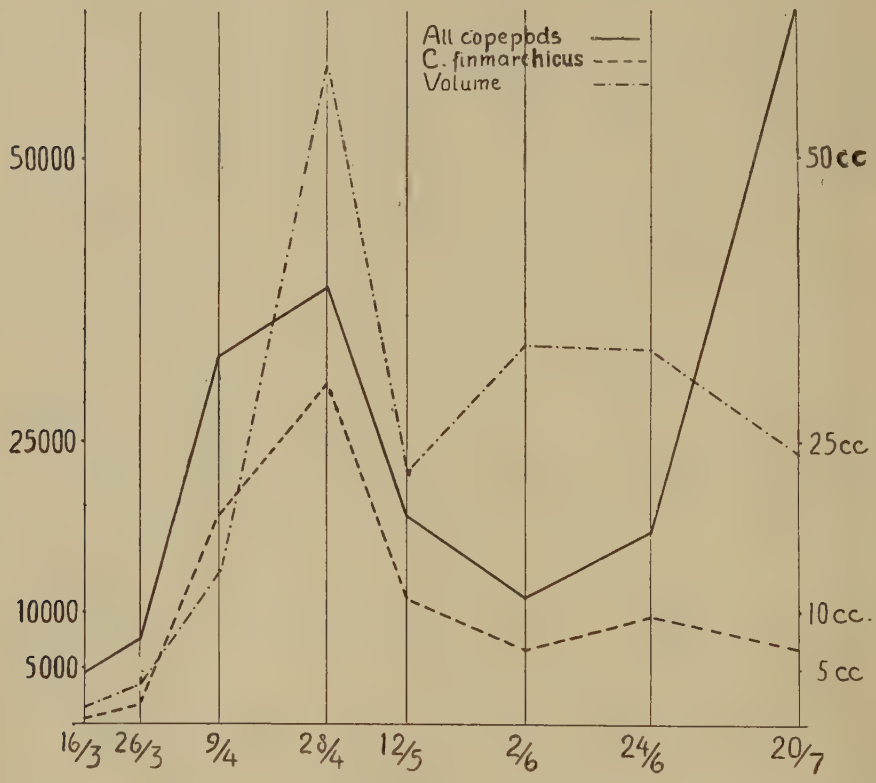

Fig. 4.

In Figures 2 and 3 an illustration is given of the variation of the numbers of different stages of *Calanus finmarchicus* at different times of the year. In Figure 2 we see the variation within each sample separately. In Figure 3 the total number of this species as well as of the different stages have been represented by separate curves.

Fig. 4 illustrates the relation between the total number of Copepods and the total number of *Calanus finmarchicus*. It will be seen from

[1]) D. Damas: Notes biologiques sur les Copépodes de la mer norvégienne. Publications de Circonstance No. 22. 1905.

Table 2 that the percentages of *Calanus finmarchicus* of all stages within the samples may vary from 5 to 85. A third curve gives the volume of the different samples. The figure illustrates the importance of the *Calanus finmarchicus* at different seasons, further the importance of this species for the volume of the sample, as long as this is a more or less pure Copepod sample. When other admixtures (such as medusae) become important (as in the summer) the correspondence between the curves for *Calanus finmarchicus* and the volume will of course be less marked.

These examples give only one amongst many applications of the method. The figures give a comparison between the hauls from one station, and in each case from the whole column of water. Other examples might compare hauls from different stations, different depths, different hours of the day etc. etc. Such samples will be found in the paper on the last year's collections which will be published by Ruud.

Biological Laboratory, University Oslo,
October 1926.

Eel Larvæ in the Faroe Channel

by

Johs. Schmidt,

Carlsberg Laboratorium, Copenhagen.

The larvæ of our common eel, "*Leptocephalus brevirostris*", are found, as we know, throughout an area of enormous extent, stretching across the Atlantic, almost from the shores of the United States, to far up in the Mediterranean, and in a north-easterly direction to the Faroe-Shetland Channel. In accordance with the direction followed by the larvæ in their migrations, the distribution in point of size is in the main such, that the youngest larvæ are found in the westernmost, and the oldest ones in the easternmost part of the area. All this has been set forth by means of charts and curves in my paper on the Breeding Places of the Eel, in the Smithsonian Report for 1924, Washington 1925. I would here refer to the two charts there given on pages 298 and 299. In the accompanying Fig. 1 I have reproduced that portion of the curve with which we are at present concerned, viz. the north-eastern portion. This should be understood as indicating the limit of occurrence of unmetamorphosed larvæ, i. e. larvæ in which the process of metamorphosis which brings them to the elver stage has not yet begun. East of this curve, or in other words, east of Long. 5° W. we find, then, only larvæ in metamorphosis, and only a very few altogether. Judging from this, it would seem that most of the specimens must already have attained the elver stage on entering the North Sea in the course of their eastward migration. The chart Fig. 1 shows, indicated by circles numbered 1 to 4, the four hitherto known localities east of Long. 5° W. where eel larvæ in metamorphosis, but not yet at the elver stage, have been found.

In the summer of 1926, the Danish research vessel "Dana" visited Iceland and the Faroes, where investigations were carried out under the supervision of Magister Å. V. Tåning. Pelagic investigations were, as usual,

made on the homeward voyage. At Station 2998, in the southern part of the Faroe-Shetland Channel, a haul was made, on the 11th of August 1926, which showed that there were many eel larvæ in the water. The position — indicated on the chart Fig. 1 by a large black spot marked No. 6 — was, precisely, 60°35′ N., 3°45′ W., and three soundings gave the depth as 366, 470 and 470 m. Twenty hauls were made in all, with a ring trawl 2 m diameter, the lengths of wire varying from 15 to 600 m;

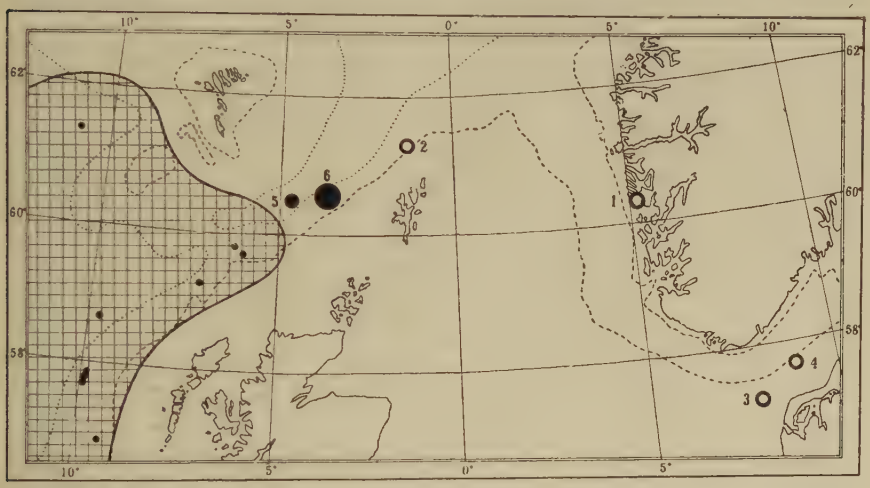

Fig. 1. The dark line round the shaded area indicates the previously known north-eastern limit of occurrence of unmetamorphosed eel-larvæ; the dark spots in this area indicate where eel-larvæ have been recorded (Danish and Scottish observations). 1—6 records of eel-larvae outside the limit of occurrence of unmetamorphosed eel-larvæ in the north-east Atlantic (1—4 data previously published).

1. Islands near Bergen. October 1907. 1 specimen: Stage III. (Prof. B. Helland-Hansen).
2. 61°17′ N. 1°22′ W. August 11. 1911. 1 specimen: Stage II. (Dr. Alex. Bowman).
3. 57°12′ N. 7°52′ E. October 2. 1922. 1 specimen: Stage IV B. (Dr. A. C. Johansen).
4. 57°41′ N. 9°04′ E. October 14. 1922. 1 specimen: Stage IV B. (Dr. A. C. Johansen).
5. 60°28′ N. 4°40′ W. May 12. 1924. 1 specimen: Stage I. ("Dana").
6. 60°35′ N. 3°45′ W. August 11-12. 1926. 297 specimens: Stage I—IV A. ("Dana").

and all save four brought up eel larvæ. The total number of these so taken was 297, the greatest number in a single haul (of 90 minutes' duration), was 86.

The size and appearance of the larvæ will be seen from the two figures 2 and 3. In both figures, distinction is made between the different stages of development. We see that the great majority are in the metamorphosis stages II and III (further as to this see Johs. Schmidt, 1906,

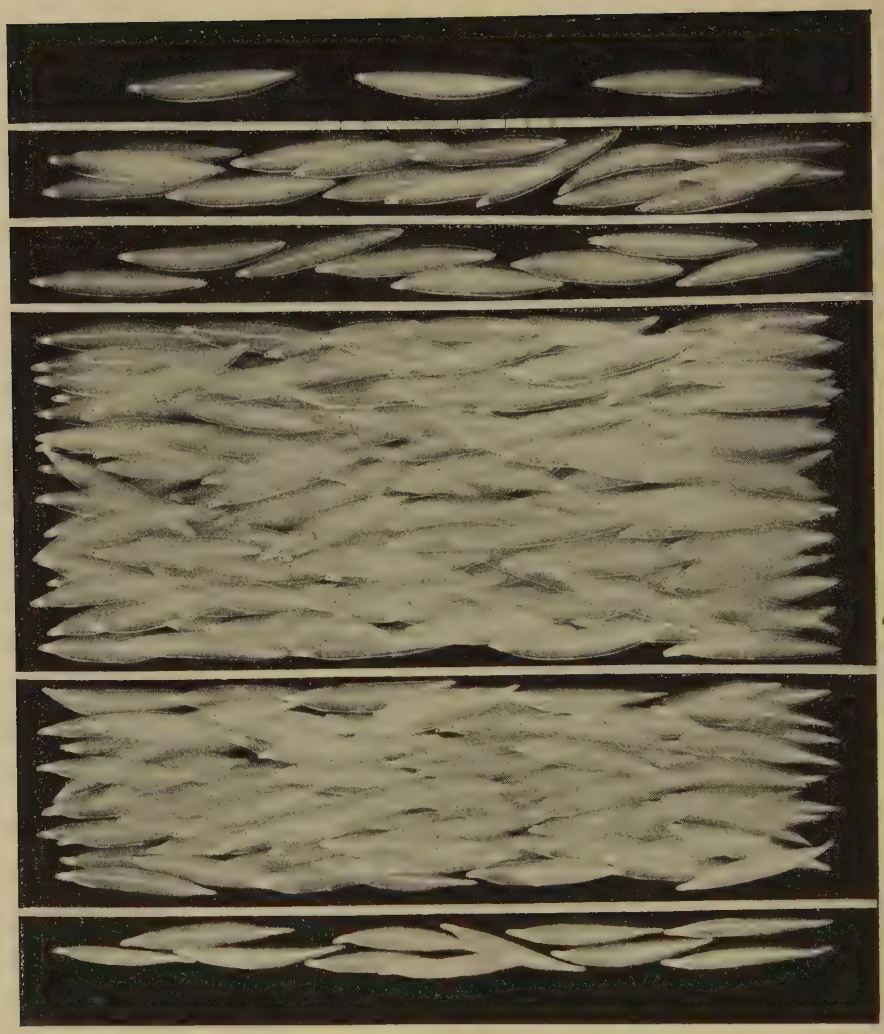

Fig. 2. Total catch of Eel-larvæ in Faroe-Shetland Channel 1926 ("Dana", St. 2998, August 11-12). Arranged according to stage of metamorphosis (I A—IV A). Centimeter scale below the top specimens. Photo Å. Vedel Tåning.

p. 249 and 1909 Pl. I)[1]). There is, however, a not inconsiderable number of larvæ which have not yet commenced their metamorphosis, *viz.*

[1]) Johs. Schmidt: Contributions to the Life-History of the Eel. Rapp. et Procès-Verbaux des Réunions. Conseil Internat. pour l'Explorat. de la Mer. Vol. IV, 1906, p. 137 *et seq.*

Johs. Schmidt: Remarks on the metamorphosis and distribution of the larvae of the Eel. Medd. fra Kommissionen for Havundersøgelser Fiskeri Bd. III, No. 3, 1909.

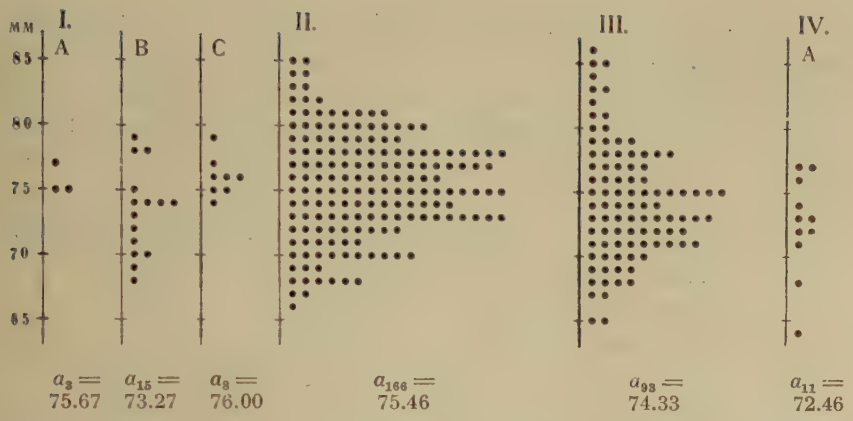

Fig. 3. Graph showing total catch of Eel-larvæ from St. 2998 arranged according to stage of metamorphosis (I A—IV A). Scale on the vertical line in mm's; each dot represents one specimen. Average length (a) of each group is noted below the graph.

abt. 9 % (Stage I in Figs. 2 and 3). The average length of the 297 specimens preserved in 5 % formol works out at 74.899 mm. For the rest, the average lengths of the various stages in the retrograde metamorphosis will be seen from Fig. 3. It is here apparent that Stage III is on the average about 1 mm shorter than Stage II (the two stages being 74.33 and 75.46 mm respectively). Otherwise, there is nothing remarkable about the lengths.

The following table shows at what depths the larvæ were found.

"Dana" Stat. 2998. — No. of Eel larvæ.

Metres of wire	Duration of hauls in hours	No. of larvæ
15	4	31
50	$1^1/_2$	3
65	$4^1/_2$	170
100	$2^3/_4$	12
150	$6^1/_2$	64
200	2	5
250	$1^1/_2$	9
300	4	3
500	2	0
600	2	0
		297

We notice that the larvæ were found for the most part in the upper water layers, the majority at a depth of 20—30 metres below the surface

(65 metres of wire out); they were even taken at the surface itself (15 m wire out). Deeper down, below 50—75 m (150 m wire out) they were scarce, and at depths beyond 200 m none were observed.

The hydrographical conditions of the locality where these eel larvæ were found will be apparent from the following table:

Dana Stat. 2998. — Hydrography. 11. 8. 1926, 7.10 a.m.

m.	t°	S°/₀₀
0	13°58	35.35
10	.56	.35
25	12°61	.35
50	10°93	.43
100	9°93	.43
150	.77	.39
200	.59	.37
350	.03	.35

The eel larvæ were found among salpæ, of which considerable quantities were brought up in the nets.

Magister Tåning has kindly furnished me with a list of the other Teleostean larvæ found in company with the eel larvæ. The commonest species were the following:

Myctophum glaciale (cc).
Lampanyctus crocodilus (c).
Maurolicus pennanti (+).
Sebastes viviparus (r).
Lophius piscatorius (r).
Argentina silus (r).
Molva byrkelange (r).
Motella sp. (c).
Pleuronectes microcephalus (cc).
Gadus aeglefinus (r).

Some few specimens of the following were also taken:

Myctophum arcticum.
— *punctatum.*
Pleuronectes cynoglossus.
Crystallogobius Nilssoni.
Liparis sp.
Fierasfer dentatus.

If we did not already know from where the eel larvæ came, the hydrographical features, as well as several of the accompanying species, would suffice to show that it was from the Atlantic. It is evident, then, that the eel larvæ, in the course of their migration from the Atlantic to the eastward, follow the southern slope of the Faroe Channel; here also they find, in the upper water layers, such oceanic conditions (relatively high salinity and temperature) as they still prefer, or demand, at this stage of their life. A glance at Fig. 1 shows that all the specimens taken east of 5° W. Long. were from the slope of the Faroe-Shetland Channel and its deep continuation eastward toward the Skagerak. This deep channel is thus unquestionably the route by which these $2^1/_4$ to $2^1/_2$ year old eel larvæ make their entry into our more easterly waters. The question now is, to what extent such an invasion of larvæ prior to the elver stage takes place; in other words, how far the "Dana" results from August 1926 represent the rule or an exception[1]). The question is one of both theoretical and practical importance, and arrangements should be made for further investigation of the matter throughout a period of years.

[1]) Danish researches have yielded but one other specimen — an unmetamorphosed larvæ 75 mm long taken by the "Dana" at 2 a.m. on the 12th of May 1924, in the Faroe-Shetland Channel, Stat. 2041 (Lat. 60°28′ N., Long. 4°40′ W., depth to bottom 1025 m). The specimen was taken just at the surface (15 m. wire out), where the temperature was 8°86 and salinity 35.37 ‰. Scottish observations on this point have been dealt with by Dr. Alex. Bowman (Distribution of the larvæ of the Eel in Scottish Waters. Fishery Board for Scotland, Sc. Invest. No. II, 1912, Glasgow 1913).

On the Influence of the Quantity of Spawning Herrings upon the stock of the following years

by

Aage J. C. Jensen.

Opposite to what is the case in most other Danish waters, the herring fishery from Bornholm (in the Baltic) is essentially based on a single race of herring viz. the South Baltic autumn herring, spawning in September—October (cf. A. C. JOHANSEN (1)). This pure stock presents a good object for an investigation into the quantitative variations of a stock of herrings in the course of time. In the annual statistics of the catch (2) we have material for estimating variations in the quantity of the stock, as the herring fishery at Bornholm is carried out so intensively that the catch may probably be taken as presenting a good picture of the stock.

From the graph (Fig. 1) of the catches 1885—1924 it appears that in this period the catch has increased considerably.

The great increase in the years 1905—11 must be ascribed to the increased intensity of the fishery. From Fig. 1 it appears that on the whole the catch has been proportionate to the number of motor-boats engaged in this fishery.

It will also be seen that the price per kg has been inversely proportionate to the catch up to the year 1915. After that year the catch and the price have on the whole been directly proportional and the latter has greatly increased. This phenomenon leads one to suppose that in these years the catch has depended on other factors than the quantity of the stock e. g. the high prices.

It is of course possible that the composition of the stock has been altered by the intensive fishery of these years; accordingly the catch during the war and the post-war catch should not be dealt with at the same time as the catches of pre-war days. A "normal curve" of the catches has been constructed in order to eliminate the effect of the

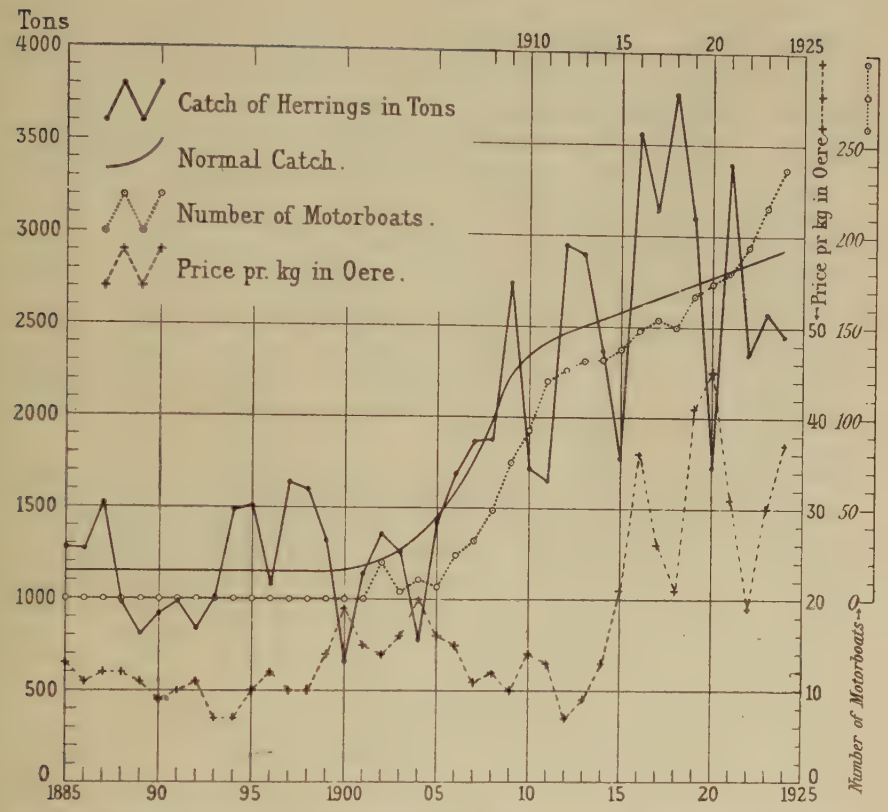

Fig. 1. Catch of herrings at Bornholm and the normal catch, compared with number of motor-boats and prize pr. kg. of herrings at Bornholm.

increase due to an increased use of motor-boats, and the percentage deviation from this curve has been calculated for the annual catches.

From the graph in Fig. 2, showing the percent anomalies, it appears that a fluctuation covering three or four years takes place. During 26 years 7 periods can be counted, each period being of 3.7 years. The amplitude will prove to be about 20 25 %. On looking at the curve of

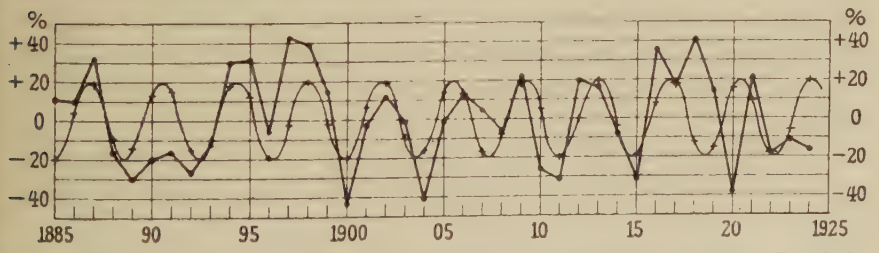

Fig. 2. Catch anomalies (percent from normal) of the herring fishery at Bornholm (broken curve) compared with a sine curve with a period of 3.7 years (see text).

the catches one must remember the way in which the catches are given by the Danish fishery statistics. Up to the year 1915 the number of herrings caught is given; thereafter the amount in kgs. is found by multiplication by a constant, the curve thus showing only the quantities.

From the year 1916 the catch is given in hls. and kgs. Now, according to a general experience of the fishermen, in a series of the years with rich herring fisheries the catch of the first year will mainly be composed of small herrings. In the following years the size will then increase, while simultaneously the number decreases. The curve indicating the number of herrings caught will therefore prove much more uneven than the curve indicating the weight, this curve being smoothed by the comparatively small weight of the big catches and the comparatively big weight of the small catches.

The periodicity will appear too, from the calculation of the correlation coefficients[1]) between the catch one year and the catch the following years. This method has been applied by Dr. J. P. Jacobsen and Dr. A. C. Johansen in examining the fluctuations of the salmon and sea-trout fishery (3).

For the years 1885—1914 we find the following correlation coefficients between the catch of one year and those of the following years:

	Displacement: Number of years.						
	1	2	3	4	5	6	7
r =	0.232	— 0.239	0.008	0.189	— 0.469	— 0.622	— 0.075
σ_r =	0.176	0.178	0.192	0.190	0.156	0.125	0.207

It is evident that the graph of this table in Fig. 3 shows the same value for the length of the period which we got from Fig. 2.

The fluctuation is found to be so regular that it will be worth while comparing it with "ideal catches" determined by a sine curve of the same period of 3.7 years. To determine the correspondence between the catch curve and the sine curve the correlation coefficients between them will be calculated.

The value for the "ideal catch" of the year t is found from $A \cos (nt - \varphi)$; A being the amplitude, n the part of the period covered by one year, φ the phase.

The sine curve is displaced by changing the values of φ; in the table below the correlation coefficients corresponding to the different values of φ are given. The values are given in graphic form in Fig. 4.

[1]) Pearson's formula $r = \frac{\Sigma p \alpha_x \alpha_y}{\sqrt{\Sigma p' \alpha_x^2 \Sigma p'' \alpha_y^2}}$ is used.

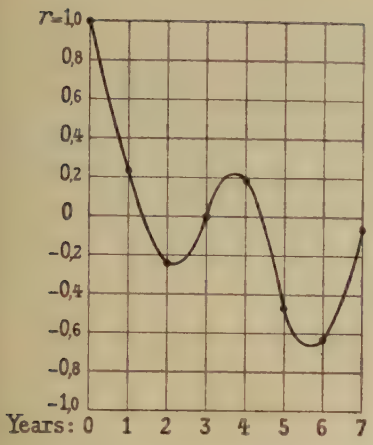

Fig. 3. The correlation coefficient r between catch-anomaly one year and the anomaly successively each of the following 7 years. The figures of the horizontal axe indicate the distance between the correlated catches.

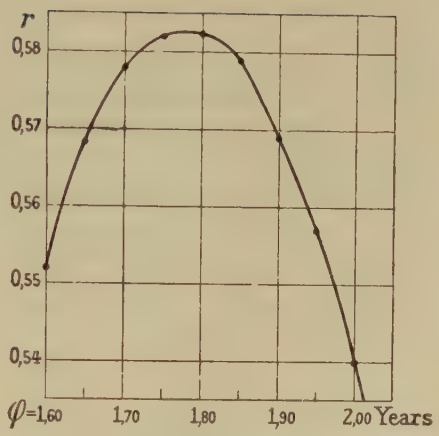

Fig. 4. Variations of the correlation coefficient r between the catch-anomaly curve and a sine curve with a period of 3.7 years and varying phase φ.

φ = 1.60	1.70	1.80	1.85	1.90	1.95	2.00	2.05 years
r = 0.552	0.578	0.585	0.579	0.569	0.557	0.540	0.520
σ_r = 0.127	0.122	0.121	0.122	0.124	0.126	0.129	0.133

The maximum correlation coefficients between the two curves are found when $\varphi = 1.8$ years. This correlation coefficient being $4.8 \times \sigma_r$ we may be sure that the periodicity of the Bornholm herring fishery is a reality. The sine curve thus found is shown in Fig. 2.

The periodicity is to be explained as a consequence of the varying amount of fry produced by the varying number of spawning herrings. The Baltic herring generally matures in its third year and the shoals of spawning herrings accordingly consist of fish three years old and more. As the herrings of the year classes III and IV in the Baltic greatly predominate over the older year classes and therefore as a rule produce the largest quantity of fry the observed periodicity can be explained in this way.

The herring fishery in the Sound shows to a slight degree a similar periodicity. Here, too, the fishery is based on a single race. About the time of each maximum and minimum of the calculated sine curve the yield of the Sound herring fishery has correspondingly been comparatively rich or comparatively poor, except for the minimum of the sine curve about the year 1892. The catches here on the whole vary more than at

Bornholm. The catch in the Sound was very much above the normal in the years 1889—91, and it shows a larger increase during the war and the period immediately following than is the case at Bornholm.

The fluctuations of many herring fisheries, e. g. the Norwegian spring herring fishery, are presumably first and foremost due to good and bad survival years. However, in all herring fisheries a period similar to that of the Bornholm herring fishery must be supposed to be one of the factors governing the quantity of the stock.

On examination of Figs. 1 and 2 a fluctuation with a period of about 11 years will be found. In order better to be able to examine this 11

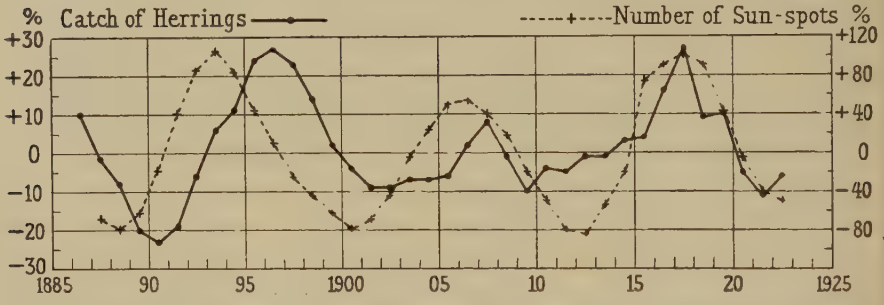

Fig. 5. Catch-anomalies of the herring fishery at Bornholm compared with percent anomalies of number of sunspots, both smoothed for every four successive years.

year-period a general smoothing for every four successive years has been carried out to eliminate the 3.7 year-period already distinguished (see Fig. 5). When the incertitude as to the war-period is borne in mind the space of time covered by the material at hand will be seen to be too short for a general determination of this period. Taken as a sine curve with a period of 11 years, a phase of 0.5 year and an amplitude of 10 % we are able to combine it with the first mentioned sine curve of the 3.7 year-period, the 1.8 year phase and the amplitude of 20 %. Then we find the correlation coefficient between the combined curve and the catch curve to be $r = 0.725$ and $\sigma_r = 0.087$.

In Fig. 5 the smoothed catch curve is compared with the 11.23 year period of solar activity.

But we must await the results of several years more before we can say whether the period of about 11 years is a reality.

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(1) A. C. Johansen: On the summer- and autumn-spawning herrings of the North Sea. Medd. Komm. f. Havundersøgelser. Ser. Fiskeri. Bd. VII. No. 5. 1924.

(2) Fiskeri Beretning (The official Danish Report). 1885—1924.

(3) J. P. Jacobsen and A. C. Johansen: On the causes of the fluctuations in the yield of some of our fisheries. I. The salmon and sea trout fisheries. Medd. Komm. f. Havunders. Ser. Fiskeri. Bd. VI. No. 5. 1921.

Directions for Staining Fish with a view to Racial Investigations

by

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Since the days of Belchier and Duhamel — that is, for nearly two centuries — it has been known that the root of *Rubia tinctorum* stains the bones of vertebrates when this substance is mixed with their food. Flourens, Kölliker and others have applied this principle to the study of skeletal growth. At the present day, as we know, synthetic *alizarine* is used for the staining of bones.

Parts not containing calcium — e. g. muscles, sinews and the like — are not affected, or but very faintly coloured, by the alizarine, and it is thus possible to bring out a sharply defined picture of such elements as fin rays, radii, vertebræ etc. in fishes, by staining with alizarine. Without staining, it will often be a matter of opinion whether there is, for instance, one ray more or less at the caudal end of the anal or dorsal fin in a flat-fish; staining with alizarine on the other hand, immediately reveals the smallest or most rudimentary ray in which there is any deposit of calcium, and thus carries the investigation, as far as is possible, beyond the limits of purely personal judgement.

In racial investigations, numerical characters are of more value than characters such as shades of colour etc. for the separation and delimitation of races, or for experimental research. And for this reason, alizarine has been extensively used in the numerous racial investigations which have been carried out during the past decade by Professor Johs. Schmidt, of the Carlsberg Laboratory at Copenhagen, since it was most desirable to get the results as accurate as possible. The staining method has also been employed in all systematic investigations with fish carried out at this Laboratory[1]), as the values for number of fin rays, for instance,

[1]) Cf. for instance: Mediterranean Scopelidæ. Report Danish oceanograph. Expeditions. Vol. II. A 7, 1918, p. 21 fl.

obtained from material stained with alizarine are generally far more reliable than those based on non-stained material — which applies to the majority of data found in ichthyological works.

Finally, it should be added that the staining method in very many cases means a great saving of time, as for instance where it is desired to procure a great number of countings with absolutely reliable figures within a short space of time.

The following notes are chiefly concerned with the staining of fishes and their young.

After numerous experiments, the following mode of procedure has been found to give the best results; it should be added, however, that the method may fail, or give but a mediocre result. The cause of this seems to be somewhat mysterious, but must be supposed to lie in the state of the material prior to preservation, and changes taking place during storage prior to use[1]).

The material is preserved in a solution of formaldehyde of abt. 4—5 %. The solution should be non-acid and slightly alkaline (pH. abt. 7—9)[2]).

After fixing for some time — the exact period depends on size of the objects, their permeability etc., but a week or so is sufficient — the formalin is washed out, by placing the object under running water for about 24 hours. If the purpose in view is, say, counting the vertebræ of fish of some size, e. g. 10 to 40 cm. in length, then the musculature on the one side should be removed with a sharp scalpel prior to staining, and the spinal column cleaned with a knife and a stiff brush under water. If it is desired to avoid shrinkage of the material, it should be put through the usual process of passing for some days through alcohol baths of different strengths until it is transferred to alcohol with alizarine. This solution is prepared as follows: the alizarine is dissolved in abt. 93 % alcohol, using for instance 500 cc. of this strong alcohol and putting in the alizarine while stirring, until the saturation point is reached. This will take abt. 1—2 grammes of alizarine. 500 cc. of strong solution will be enough to stain a great quantity of material.

A suitable quantity of the strong alizarine solution is added to

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[1]) It seems as if material which is not quite fresh at time of preservation generally takes the stain better than specimens which have been preserved when perfectly fresh. Very old material is often difficult to stain (owing to the change of acidity).

[2]) See W. R. G. Atkins: The Preparation of permanently non-acid formalin for preserving calcareous specimens. Journal Marine Biological Association. Plymouth. N. S. Vol. XII. 4. 1922, p. 792—794.

70 % alcohol in which the objects are to be stained. The solution should be slightly acid.

A suitable solution for staining small fish abt. 4 cm. length is the following: 20 cc. of the strong alizarine solution is added to 500 cc. 70 % alcohol and to this non-acid solution is further added 4—5 drops 5 % acetic acid (CH_3COOH).

Staining proceeds better at higher temperatures than ordinary indoor temperature — e. g. at abt. 25° C. If rapid staining is required, and there is no objection to some deposit of colour in musculature etc. at the same time, a stronger solution of alizarine in 70 % alcohol can be used; as a rule, however, and always when dealing with valuable material, or delicate objects such as tiny fish in the youngest stages, it is certainly better to use a weak solution, (e. g. for small postlarval fish, 5—10 cc. of the 93 % alcohol solution to 500 cc. 70 % alcohol) and let it stand longer in a warm place; this gives remarkably fine results. The staining will take about 24 hours, but it is impossible to state any definite time, as it depends on the size and number of the objects, concentration of solution etc. The liquid in which the objects are immersed should be shaken now and again while the process is going on; and there should always be plenty of solution to each batch of material.

When stained, and after suitable preparation, the counting of elements such as vertebræ, fin rays etc. can, in the case of larger fishes, be proceeded with at once. It is often a help, and a saving of time, in counting vertebræ, to mark every tenth vertebra with a touch of indian ink. Smaller objects, such as young fish of 4—5 cm. or under are best dealt with (under the microscope) after being passed, through different strengths of alcohol into xylol, as a clearing medium; they are then placed under a slice of glass in a glass dish of xylol. It is often necessary to remove the musculature etc. on one side or both, in order to expose the spinal column clearly to view; this is very easily done with a safety razor blade of the flexible type.

For valued assistance my obligations are due to Prof. Johs. Schmidt, Docent R. H. Stamm and Mr. E. Svarrer.

Biological Statistics of the Stocks of Fish.

[The following papers, by Dr. Bückmann and Mr. Hodgson, are published in fulfilment of Recommendation No. 6 of the Consultative Committee (Rapp. Proc. Verb. XLI, 1926). Ed.].

I. Vorwiegen des Jahrgangs 1922 im Schollenbestande der Deutschen Bucht.

Ein Beitrag zur Frage der Fluktuationen

von

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Verschiedentlich ist versucht worden, die Grösse der Bruterzeugung des Schollenbestandes in der Nordsee in den einzelnen Jahren zu bestimmen. In der Tat ist es von der grössten Bedeutung für uns zu wissen, ob die Zeugung sich im Wesentlichen gleich bleibt bzw. sich in gleichmässiger Weise verändert oder ob sie von Jahr zu Jahr innerhalb weiter Grenzen schwankt. Während z. B. eine fortgesetzte Abnahme der Brutproduktion sehr für die Verminderung des Bestandes durch die Fischerei sprechen würde, müsste man starke Schwankungen bei gleich bleibender Intensität der Befischung auf anderweitige — physikalische oder biologische — Faktoren zurückführen.

Die Bestimmung der Bruterzeugung ist bisher auf zwei Wegen mit Erfolg versucht worden: durch Untersuchung der Zahl der Fischeier und -Larven mit quantitativ fischenden Planktonnetzen und durch Ermittlung der Menge der Jungschollen der ersten Bodenstadien (0-Gruppe) in den Fängen kleiner Schleppnetze.

Für die Frage, welche Fischmenge jeder einzelne neue Jahrgang dem Nutzfischbestande des Meeres zuführt, ist die zweite Art der Untersuchung wohl sicher die geeignetere, denn gerade auf den vorher durchlaufenen planktonischen Entwicklungsstufen ist wahrscheinlich die Zehrung gewaltig. Mit Recht ist die Frage aufgeworfen worden, ob die Jungfischmenge in höherem Masse von der Laichmenge abhängig sei oder von dem Grade dieser Zehrung, die nach den äusseren Bedingungen, unter denen die Eier und Larven sich entwickeln, möglicherweise sehr verschieden sein kann. Dies Problem könnte gelöst werden, wenn quanti-

tative Eier- und Larvenuntersuchungen und zuverlässige Dichtebestimmungen an Bodenstadien parallel miteinander ausgeführt würden[1]).

Die bisher veröffentlichten Tatsachen scheinen darzutun, dass man bei Anwendung beider Methoden in der Tat zu verschiedener Beurteilung der Dichte eines Jahrgangs kommen kann. Bekanntlich fand Mielck, dass das Jahr 1920 ein ungewöhnlich gutes Laichjahr war. Die Eimenge war etwa 2—3mal so gross wie die in den Vorkriegsjahren beobachtete. Dagegen ergaben Johansens Untersuchungen[2]) über die Dichte der Jungschollenbevölkerung, dass der Jahrgang 1920 als 0- und I-Gruppe in seinen Zonen 1—5 (Fanö-Hanstholm) keineswegs aussergewöhnlich stark, vielmehr unter dem Vorkriegsmittel war.

Die von Johansen untersuchte Region ist aber wohl nicht das wichtigste Gebiet für die ersten Lebensjahre der Scholle. Vorbereitende deutsche Untersuchungen über Menge und Verbreitung der jüngsten Bodenstadien im Jahre 1926 zeigen, dass im innersten Winkel der Deutschen Bucht weit höhere Zahlen von 0-Gruppe gefangen werden können als an der dänischen Küste. So wurden im Elbgebiet von Cuxhaven bis Scharhörn Riff mit dem Johansenschen Jungfischtrawl[3]) in einer Stunde im Mittel ca. 2700 Schollen des ersten Lebensjahres gefangen; das ist das 6-fache von dem Fang, den Johansen im günstigsten Jahre (1912) für die reichste seiner Zonen anführt.

Leider ergeben sich aber bei den Jungfischuntersuchungen mit dem Schleppnetz gerade in der inneren Deutschen Bucht Schwierigkeiten, die die Ergebnisse bis zu einem gewissen Grade unsicher machen. Es zeigte sich bei unseren Fängen, dass auf dicht beieinander gelegenen Stationen z. T. sehr verschiedene Fangerträge erzielt wurden, ein Umstand, der das Vertrauen in die Zuverlässigkeit der Befunde zu erschüttern geeignet ist, zumal es bei der grossen Veränderlichkeit des Bodenreliefs im Elbgebiet geradezu unmöglich ist, in aufeinander folgenden Jahren genau gleichgelegene Stationen zu befischen. Eine weitere Schwierigkeit liegt in dem grossen Tidenhub und den starken Gezeitenströmen. Letztere erlauben es stellenweise nur bei Stauwasser, mit dem leichten Gerät einwandfrei zu fischen. Bei Hochwasser ist aber ein viel grösseres Gebiet überflutet als bei Niedrigwasser, und die Schollen, die bei Ebbe mehr und mehr in den Prielen[4]) zusammengedrängt werden, scheinen sich

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[1]) Vergleiche hierzu die Ausführungen von Mielck in den Ber. d. Deutsch. wiss. Komm. N. F. Bd. II Heft 4, S. 17—19.

[2]) Medd. fra Komm. f. Havunders. Ser. Fiskeri Bd. VI Nr. 8. 1922.

[3]) Stets mit einer Kette von der Länge des Grundtaues beschwert.

[4]) Rinnen, in denen bei Ebbe das Wasser abläuft und die auch bei Niedrigwasser noch Wasser führen.

mit zunehmender Flut über das Watt zu verteilen. Als weitere erschwerende Faktoren kommen die auch von JOHANSEN für die dänische Küste erwähnten hinzu, wie Wasserklarheit und Witterungseinflüsse. So haben wir eine Fülle von Bedingungen, die die Zuverlässigkeit und Vergleichbarkeit der Ergebnisse herabzusetzen vermögen.

Es ist nun aber möglich[1]), die Auswirkungen sehr starker Schwankungen in der Jungfischproduktion auch an der Zusammensetzung der Schollenschwärme noch wenn sie einige Jahre älter sind zu erkennen. Unter Vermeidung der unzuverlässigen Dichtebestimmungen kann das durch die Kontrolle der prozentualen Anteile der einzelnen Altersgruppen in wissenschaftlichen Kurrenfängen auf den Jungschollengründen der Deutschen Bucht geschehen. Natürlich hat auch ein solches Verfahren seine Unsicherheiten. Einmal können vielleicht sehr grosse Veränderungen in der Befischungsstärke auf den Jungfischgründen die einzelnen Jahrgänge verschieden beeinflussen. Wir haben jedoch mindestens für die letzten Jahre kein Anzeichen dafür, dass die Fischerei in der Deutschen Bucht so ungewöhnlich ungleichmässig gewesen sei. — Ferner ist die Deutung der Befunde nicht einfach. Das beobachtete Vorwiegen eines bestimmten Jahrganges braucht nicht unbedingt dadurch hervorgebracht zu sein, dass er selbst besonders reich ist, sondern kann ebensogut darauf beruhen, dass einer oder mehrere der anderen mit ihm zusammen gefangenen Jahrgänge ungewöhnlich arm gewesen sind. Eine Entscheidung darüber, welche von diesen beiden Möglichkeiten vorliegt, kann nur getroffen werden, wenn man den Jungfischgrund fortgesetzt, möglichst in jedem Jahre, untersucht und so Auftreten und Ablauf der Erscheinung genau beobachten kann.

Ein Versuch, aus dem Vergleich von Altersproben aus einer Reihe von Jahren Schlüsse auf die Stärke einzelner Jahrgänge zu ziehen, ist z. B. in der Arbeit von HEINCKE und BÜCKMANN im »Fischerboten« 1926 (Jahrg. XVIII, 3) gemacht, wo die besondere Häufigkeit der Jahrgänge 1919 und 1920 in den Fängen bei Helgoland von 1922 bis 1925 verfolgt werden konnte. Dies Ergebniss steht für den Jahrgang 1920 in Einklang mit den oben erwähnten Befunden der Eieruntersuchungen, im Gegensatz aber zu denen JOHANSENS über die Dichte der 0-Gruppe. Andererseits kommt aber K. SMITH (Medd. fra Komm. f. Havunders., Ser. Fiskeri Bd. VII Nr. 4) auf Grund der Altersuntersuchungen und Dichtebestimmungen auf den Jungfischgründen von Hornsriff im Herbst 1922 ebenfalls zu dem Schluss, dass die Jahrgänge 1920 und 1921 sehr viel stärker seien als die untersuchten Vorkriegsjahrgänge.

[1]) Siehe auch HEINCKE in: Der Fischerbote 1916, S. 183 und BLEGVAD in: Dansk Fisk. Tid. 1926 Nr. 25, S. 297.

Da man nur auf Grund von systematisch gesammeltem, nach Zeit, Fangort und -Gerät vergleichbarem Material derartige Fragen fördern kann, wurde seit 1924 fortgefahren, bei Helgoland ein tunlichst grosses, mit dem bereits vorhandenen vergleichbares Altersbestimmungsmaterial zu beschaffen. Vielleicht genügt sein Umfang nicht allen Anforderungen; es musste aber beim Sammeln des Materials Rücksicht darauf genommen werden, dass für die Aufarbeitung nur eine Kraft zur Verfügung stand. Daraus ergibt sich aber andererseits der Vorzug, dass alle diese Bestimmungen mit dem gleichen persönlichen Fehler behaftet sind, ein Vorzug, den man m. E. nicht gering veranschlagen darf.

Die Altersuntersuchungen wurden bei Helgoland in zwei Reihen ausgeführt: eine an Material vom Juli und Anfang August und eine von September und Anfang Oktober. Die Stationen, auf denen Otolithenproben gesammelt wurden, liegen südlich bis westlich, nordwestlich und nördlich der Insel in einem Umkreise von etwa 10 Seemeilen. (Nur die Proben vom September 1925 enthalten Material von zwei weiter abgelegenen Stationen, doch stimmt dies in der Zusammensetzung sehr gut mit dem vom Helgoland überein.)

Die Beobachtungen des Jahres 1926 bestätigen nun eine Vermutung, die mir im Laufe der früheren Untersuchungen bereits gekommen war. Es zeigt sich nämlich, dass der Jahrgang 1922 in der Deutschen Bucht unverhältnismässig stark in den Vordergrund tritt. Das lässt sich vom Jahre 1924 an, wo der Jahrgang 1922 als II-Gruppe bei Helgoland zuerst in grösserer Menge gefangen wurde, bis zum Jahre 1926, wo er die IV-Gruppe bildet, deutlich verfolgen. Es erscheint angebracht, die bisherigen Befunde zu veröffentlichen, um die Aufmerksamkeit der interessierten Forscher hierauf zu lenken. Vielleicht ergibt sich aus ihrem Material Antwort auf die Frage, ob das Hervortreten des Jahrgangs 1922 eine lokale Erscheinung in der inneren Deutschen Bucht oder aber im Nordseegebiet allgemein verbreitet ist. Erst nach Klärung dieser Frage und weiterer Beobachtung wird man sich ein Urteil über die Ursache des Phänomens bilden können.

Die Ergebnisse der Altersuntersuchungen bei Helgoland von 1924—1926 sind in Tabelle 1 enthalten. Schon in dieser Zusammenstellung fällt es auf, dass der Jahrgang 1922 in September-Oktober (Tab. 1 A) aller drei Jahre den dichtesten Wert bildet. Dasselbe gilt für Juli-August 1925 und 1926 (Tab. 1 B), während in dieser Reihe die Menge des Jahrgangs als II-Gruppe im Untersuchungsjahr 1924 zwar gross ist, aber von dem Jahrgang 1921 als III-Gruppe doch noch übertroffen wird. Es ist ja bekannt (S. Heincke in: Beteiligung Deutschlands an der I. M. F., Jahresber. IV-V, Anhang p. 36), dass die Schollen des zweiten

Tabelle 1. Zusammensetzung des Schollenbestandes bei Helgoland aus Altersgruppen.

A. September—Oktober.

		I	II	III	IV	V	VI	VII	VIII +	Zus.
1924	♂	7	46	27	14	8	1	—	—	103
	♀	13	53	32	20	7	2	—	—	127
Geburtsjahr ...		1923	1922	1921	1920	1919	1918	1917	1916-	
1925	♂	18	81	193	90	35	9	1	—	427
	♀	6	71	169	90	55	12	1	1	405
Geburtsjahr ...		1924	1923	1922	1921	1920	1919	1918	1917-	
1926	♂	10	43	86	224	90	33	9	—	495
	♀	6	69	105	258	79	22	8	2	549
Geburtsjahr ...		1925	1924	1923	1922	1921	1920	1919	1918	

B. Juli—August.

		I	II	III	IV	V	VI	VII	VIII +	Zus.
1924	♂	5	79	109	57	25	2	1	—	278
	♀	2	93	142	72	32	4	—	1	346
Geburtsjahr ...		1923	1922	1921	1920	1919	1918	1917	1916-	
1925	♂	1	51	286	176	73	28	8	—	623
	♀	1	60	269	167	95	43	5	1	640
Geburtsjahr ...		1924	1923	1922	1921	1920	1919	1918	1917-	
1926	♂	1	39	116	312	99	34	15	2	618
	♀	2	40	101	258	112	38	5	4	560
Geburtsjahr ...		1925	1924	1923	1922	1921	1920	1919	1918-	

und dritten Lebensjahres bei Helgoland im Frühsommer noch spärlich sind und erst im Herbst in grösserer Zahl dies Gebiet erreichen.

Deutlicher noch wird das Hervortreten des Jahrgangs 1922 in Tabelle 2, die für beide Reihen die prozentuale Zusammensetzung des Bestandes (♂ + ♀) in den drei Jahren angibt. Zum Vergleich ist die Alterszusammensetzung eines Vorkriegsjahres (1905 und 1906) und eines weiteren Nachkriegsjahres (1922 und 1923) mit aufgeführt. — Während im September

Tabelle 2. Prozentuale Zusammensetzung des Schollenbestandes bei Helgoland aus Altersgruppen.

A. September—Oktober.

Untersuch. Jahrgang	I	II	III	IV	V	VI	VII	VIII +	Unters. Zahl
1905	1.2	36.1	34.4	22.8	5.1	0.3	0.1	—	1447
Geburtsjahr ...	1904	1903	1902	1901	1900	1899	1898	1897-	
1922	2.8	25.9	53.7	11.4	5.3	0.7	0.1	—	575
Geburtsjahr ...	1921	1920	1919	1918	1917	1916	1915	1914-	
1924	8.7	43.0	25.7	14.8	6.5	1.3	—	—	230
Geburtsjahr ...	1923	1922	1921	1920	1919	1918	1917	1916-	
1925	2.9	18.3	43.5	21.6	10.8	2.5	0.2	0.1	832
Geburtsjahr ...	1924	1923	1922	1921	1920	1919	1918	1917-	
1926	1.5	10.7	18.3	46.2	16.2	5.3	1.6	0.2	1044
Geburtsjahr ...	1925	1924	1923	1922	1921	1920	1919	1918-	

B. Juli—August.

Untersuch. Jahrgang	I	II	III	IV	V	VI	VII	VIII +	Unters. Zahl
1906	1.3	35.9	46.5	13.1	3.0	0.2	0.0	—	1532
Geburtsjahr ...	1905	1904	1903	1902	1901	1900	1899	1898-	
1923	—	13.7	43.7	33.5	7.5	1.2	0.5	—	375
Geburtsjahr ...	1922	1921	1920	1919	1918	1917	1916	1915-	
1924	1.1	27.5	40.2	20.7	9.1	1.0	0.2	0.2	624
Geburtsjahr ...	1923	1922	1921	1920	1919	1918	1917	1916-	
1925	0.1	8.8	43.9	27.2	13.3	5.6	1.0	0.1	1263
Geburtsjahr ...	1924	1923	1922	1921	1920	1919	1918	1917-	
1926	0.3	6.7	18.4	48.4	17.9	6.1	1.7	0.5	1178
Geburtsjahr ...	1925	1924	1923	1922	1921	1920	1919	1918-	

des Vorkriegsjahres 1905 (Tab. 2 A) die Altersgruppen II und III einander annähernd gleich sind, überwiegt im Vergleichsjahr 1922 die III-Gruppe beträchtlich, doch steht die II-Gruppe an zweiter Stelle. Diese beiden Gruppen werden von den uns bereits als sehr stark bekannten Jahrgängen 1920 und 1919 gebildet. Sie treten uns zwei Jahre später,

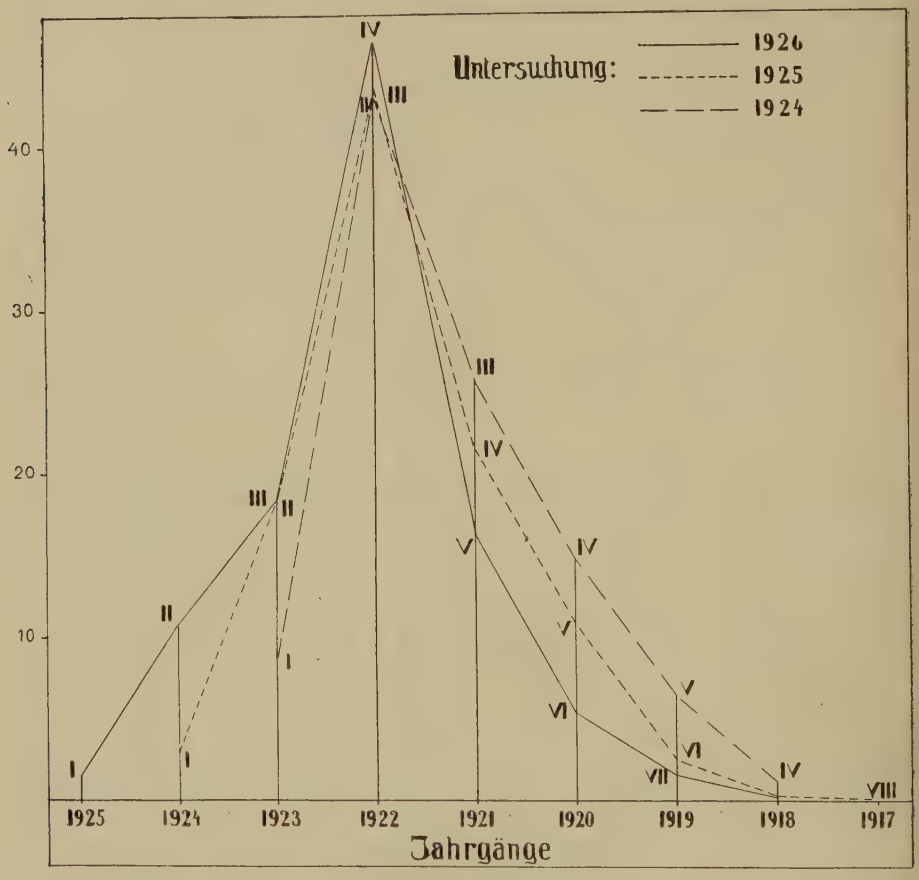
1924, als IV- und V-Gruppe entgegen und sind prozentual stärker vertreten als die entsprechenden Altersgruppen im Untersuchungsjahr 1922. Doch werden sie jetzt in den Hintergrund gedrängt durch die Schollen des Geburtsjahres 1922 (in der II-Gruppe), die 43 % des Bestandes ausmachen und damit auch die Altersgruppe III (im Vergleichsjahr 1922 die dichteste) bei weitem übertreffen. Im folgenden Jahre bildet derselbe Jahrgang 1922, jetzt als III-Gruppe, wieder den dichtesten Wert, seinerseits den Wert der II-Gruppe, ja auch den der III-Gruppe im Vergleichsjahr 1905 weit überragend, trotzdem die Kriegsbrutjahrgänge 1919 und 1920 als V- und VI-Gruppe einen weit grösseren Prozentsatz stellen (13,3 %), als die entsprechenden Gruppen in dem Vorkriegsjahre (5,4 %). — Abermals ein Jahr später, 1926, liegt der dichteste Wert bei der IV-Gruppe, also wieder bei dem Jahrgang 1922, und die jüngeren Gruppen stellen einen ganz auffallend geringen Anteil des Bestandes, Verhältnisse, wie wir sie sonst nur während des Krieges und kurz nach dessen Schluss beobachtet haben.

Diese Befunde werden durch die der Juli-Augustreihe (Tab. II B) vollständig gestützt. In den Vergleichsjahren 1906 und 1923 bildet hier beidemal die III-Gruppe den dichtesten Wert. Während aber 1906 die Altersgruppe II den nächsthöchsten Prozentsatz hat, entfällt dieser 1923 auf den Kriegsbrutjahrgang 1919 (IV-Gruppe), demgegenüber der Jahrgang 1921 als II-Gruppe nur einen mässigen Anteil aufweist. Im folgenden Jahre, 1924, tritt der Jahrgang 1922 in die II-Gruppe, und sogleich ist deren Anteil wieder viel grösser. Allerdings wird der Wert dieser Gruppe im Vergleichsjahre 1905 nicht erreicht, und dafür dürften die folgenden beiden Gründe ausschlaggebend sein: einmal entgeht infolge der geringeren Wachstumsgeschwindigkeit nach dem Kriege ein grösserer Anteil dieser jungen Schollen dem Netz als früher (ein Umstand, der auch bei den anderen Werten der ersten Nachkriegsjahre sinngemäss in Anrechnung zu bringen ist), und zweitens verschieben die dichten Jahrgänge 1920 und 1919 als IV- und V-Gruppe die prozentuale Beteiligung zuungunsten der jüngeren Schollen. Von 1925 an sehen wir aber auch hier den Jahrgang 1922 im Maximum, sowohl in diesem Jahre in der III-Gruppe wie 1926 in der IV-Gruppe, und keine der anderen Altersstufen erreicht auch nur annähernd denselben Wert.

Eine bildliche Darstellung dieser auffälligen Erscheinung geben Fig. 1 und 2. Sie zeigen den prozentualen Anteil der einzelnen Geburtsjahrgänge am Bestande in den drei Jahren 1924—1926. Die Höhe der Ordinaten gibt also für jeden Jahrgang den jeweiligen Prozentsatz an, der ihm in verschiedenen Altersgruppen zufällt. Diese sind durch die römischen Ziffern am Endpunkt der Ordinate kenntlich gemacht. Den

Jahrgang 1922 sehen wir als II-, III- und IV-Gruppe. Sein Vorwiegen in den meisten Untersuchungen und seine relativ grosse Bedeutung als II-Gruppe auch in der Juli-Augustreihe treten deutlich hervor. Das

Fig. 1. Prozentuale Beteiligung der einzelnen Jahrgänge am Schollenbestande bei Helgoland im September 1924—1926.



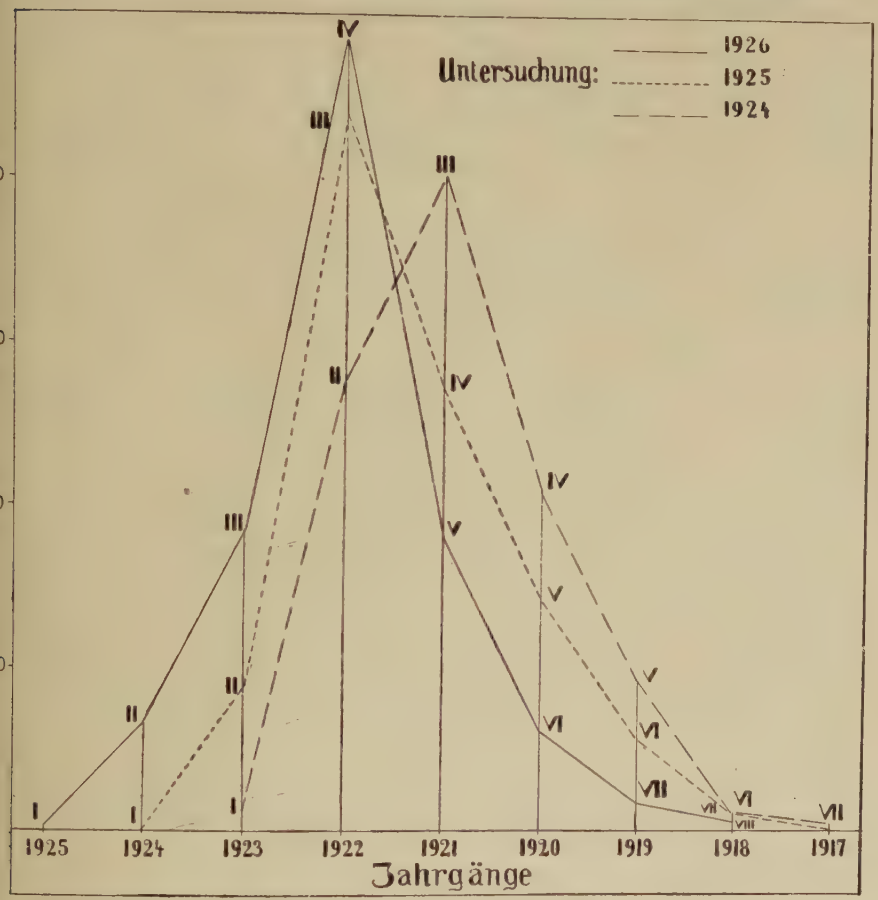
Die römischen Ziffern bezeichnen die Altersgruppe, in der der betr. Jahrg. auftritt.

Bild erinnert in auffallendem Masse an die Befunde Hjorts und seiner Mitarbeiter über die Zusammensetzung der norwegischen Herings- und Kabeljaufänge nach Jahrgängen (Rapp. Proc. Verb. 20., Journ. du Conseil I, 1).

Unser Material erlaubt es festzustellen, dass diese Erscheinung nicht auf die nächste Nähe von Helgoland beschränkt sondern in der Deutschen Bucht weiter verbreitet ist. Dazu können die Altersbestimmungen von

den Poseidonfahrten der letzten Jahre benutzt werden. Bei diesen Fahrten wurden auf je einem Schnitt von der nordfriesischen und ostfriesischen

Fig. 2. Prozentuale Beteiligung der einzelnen Jahrgänge am Schollenbestande bei Helgoland im Juli—August der Jahre 1924—1926.



Die römischen Ziffern bezeichnen die Altersgruppe, in der der betr. Jahrg. auftritt.

Küste nach dem tieferen Wasser zu auf allen Stationen möglichst viele Otolithen genommen. Natürlich war es in den meisten Fällen unmöglich, sämtliche Schollen eines Fanges zu untersuchen, da deren Zahl in unseren Gewässern bei weitem zu gross ist[1]). Es wurden aber tunlichst alle

[1]) Die Fänge werden mit dem grossen Scherbrettnetz von 142 Fuss Grundtaulänge gemacht.

Tabelle 3. Altersuntersuchungen auf dem Norderney-Schnitt September 1925 und 1926.

A. Prozentuale Zusammensetzung der Otolithenproben aus Altersgruppen.

Untersuchungsjahr	I	II	III	IV	V	VI	VII	VIII +	Unters. Zahl
1925	11.7	21.9	36.1	16.1	10.4	3.2	0.4	0.2	1391
Geburtsjahr...	1924	1923	1922	1921	1920	1919	1918	1917-	
1926	17.6	35.0	12.3	20.9	7.7	3.7	1.7	1.1	1421
Geburtsjahr...	1925	1924	1923	1922	1921	1920	1919	1918-	

B. Absolute und prozentuale Zusammensetzung der Gesamtfänge aus Altersgruppen. (Errechnete Werte.)

1925				Altersgruppe	1926				
Gesamtzahl 5 Stund.	σ	%	Geburtsjahr		Gesamtzahl 6 Stund.	σ	Gesamtzahl 5 Stund.	%	Geburtsjahr
372	±18	12.6 %	1924	I	1149	±65	958	17.9 %	1925
680	±25	23.1 %	1923	II	2633	±84	2194	40.8 %	1924
1049	±28	35.6 %	1922	III	725	±55	604	11.3 %	1923
437	±21	14.8 %	1921	IV	1119	±61	932	17.4 %	1922
294	±18	10.0 %	1920	V	444	±42	370	6.9 %	1921
96	±11	3.3 %	1919	VI	199	±27	166	3.2 %	1920
18	± 4.5	0.6 %	1918	VII	102	±17	85	1.6 %	1919
4	± 3.4	0.1 %	1917-	VIII+	62	±14	52	0.9 %	1918-
2950					6433		5361		

Die theoretische Standartabweichung ist berechnet unter Berücksichtigung der Einzelfehler der für ♂ und ♀ getrennt behandelten Fangzahlen der einzelnen Stationen.

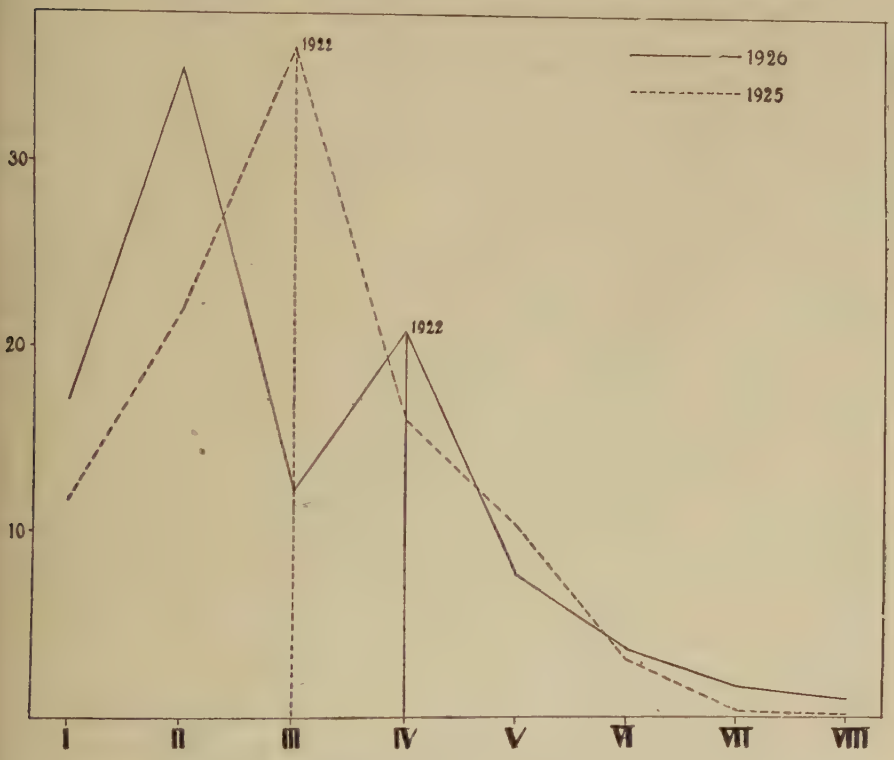
Schollen aus einem Korb des Fanges genommen, der beim Öffnen des Steertes unter denselben gestellt wurde. Dadurch konnte erzielt werden, dass die Probe ohne subjektive Fehlerquelle wahllos genommen wurde und zumeist in ihrer Längenzusammensetzung ein hinreichend repräsentatives Bild des Gesamtfanges bot.

Unseren Zwecken kann nun ein Vergleich der Altersuntersuchungen auf dem Schnitt querab Norderney im September der Jahre 1925 und 1926 dienen. Eine Vereinigung aller Otolithenproben aus 5 Fängen von 1925 und 6 Fängen von 1926 zwischen Dove Tief Tonne bei Norderney

und einem Punkte etwa 25 Seemeilen westlich von Helgoland (9—37 m Tiefe) ergibt für die beiden Jahre das Bild, das Tabelle 3 A zeigt.

Wir finden, dass im September 1925 der Gipfel bei der III-Gruppe

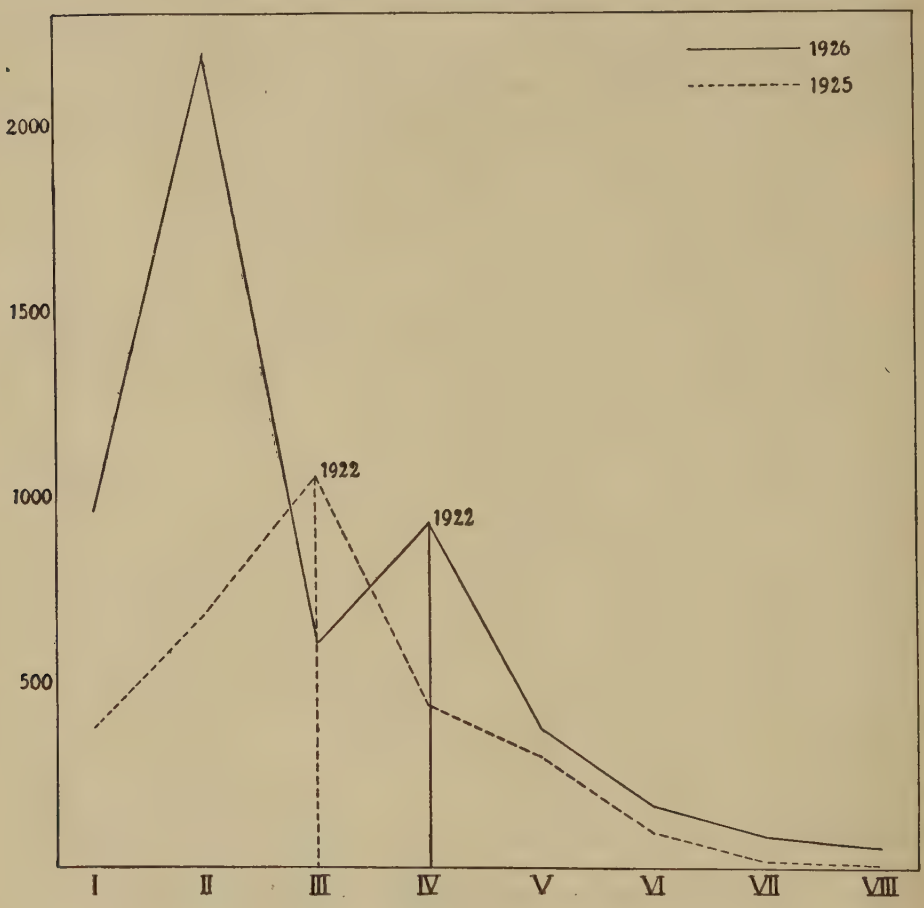
Fig. 3. Prozentuale Zusammensetzung der Otolithenproben vom Norderney-Schnitt aus Altersgruppen. September 1925 und 1926.



Die Ordinaten für den Jahrgang 1922 sind eingezeichnet.

liegt (Jahrgang 1922), auf die 36 % des Bestandes entfallen gegen nur 16 % für die IV-Gruppe. Mit dem Aufrücken des Jahrgangs 1922 in die IV-Gruppe hat sich dies Verhältnis in den Untersuchungsreihen von 1926 umgekehrt: die IV-Gruppe stellt jetzt 21 %, während die III-Gruppe auf 12 % zusammengeschrumpft ist. Weiter aber sehen wir eine neue interessante Erscheinung: der dichteste Wert liegt in diesem Jahre bei der II-Gruppe (Jahrgang 1924), die von 22 % auf 35 % angewachsen ist. Es ist an sich möglich, dass dies Verhalten auf eine besondere Dichte auch des Jahrganges 1924 deutet. Wir müssen aber bedenken, dass im Jahre 1925 die II-Gruppe von dem Jahrgang 1923 ge-

Fig. 4. Zusammensetzung der Schollenfänge vom Norderney-Schnitt aus Altersgruppen. Auf 5 Fangstunden berechnete absolute Werte. September 1925 und 1926.



Die Ordinaten des Jahrgangs 1922 sind eingezeichnet.

bildet wurde und dass dieser auch in den Helgoländer Fängen als II-Gruppe und selbst als III-Gruppe aussergewöhnlich schwach war. Deshalb ist es auch denkbar, dass das Vorwiegen der II-Gruppe (wie 1926) in diesem Gebiet normal, ihr Zurücktreten (wie 1925) dagegen ungewöhnlich ist. Leider fehlt es an weiterem Vergleichsmaterial, um diese Frage entscheiden zu können. — Fig. 3 veranschaulicht die prozentuale Zusammensetzung der Otolithenproben. Auf den Ordinaten sind aber hier die Werte für die einzelnen Altersgruppen (nicht wie in Fig. 1 und 2 für die Jahrgänge) abgetragen. Die Ordinaten des Jahrgangs

1922 sind eingetragen, für 1925 als unterbrochene, für 1926 als ausgezogene Linie.

Ganz richtig ist dies Bild von der Alterszusammensetzung des Bestandes jedenfalls nicht, da ja bei der Vereinigung der Otolithenproben nicht die Grösse der einzelnen Fänge berücksichtigt wird. Wir können jedoch diesen Fehler auszugleichen versuchen, indem wir aus der Zusammensetzung der Probe die des ganzen zugehörigen Fanges errechnen und diese Reihen nun ihrerseits vereinigen. Wir vergleichen zunächst die so gewonnenen absoluten Werte, die Alterszusammensetzung des Gesamtfanges (Tab. 3 B). Da im Jahre 1926 6 einstündige Fänge, 1925 aber nur 5 im gleichen Gebiet gemacht wurden, so sind in einer besonderen Spalte die Werte von 1926 auf 5 Trawlstunden umgerechnet. Es zeigt sich dann, dass 1926 in der gleichen Fangzeit fast doppelt soviel Schollen gefangen sind wie 1925. Zum grossen Teil ist das auf die bedeutende Menge der II-Gruppe im ersteren Jahre zurückzuführen. Aber auch in allen anderen Altersgruppen sind die Fänge von 1926 grösser. Die einzige Ausnahme ist die III-Gruppe. Von dieser wurden im Jahre 1925, wo sie von dem Jahrgang 1922 gebildet wurde, mehr gefangen als 1926 (Jahrgang 1923). Fig. 4 veranschaulicht die absolute Fangmenge in den einzelnen Altersgruppen, auf 5 Stunden berechnet. Die Ordinaten für den Jahrgang 1922 sind wieder eingezeichnet. — Berechnen wir aus diesen absoluten Werten die Prozentualreihen (Tab. 3 B), so zeigt sich, dass diese von den aus der Otolithenprobe gebildeten nicht sehr stark abweichen. Doch tritt für 1926 der Anteil der II-Gruppe in den ersteren sogar noch mehr hervor.

Um zu zeigen, dass auf allen Stationen des Norderney-Schnittes im Jahre 1925 die III-Gruppe am stärksten ist, mit dem Heranwachsen des Jahrgangs 1922 zur IV-Gruppe aber im folgenden Jahre diese Altersstufe die III-Gruppe überwiegt, sind Fig. 5 A und 5 B angefügt. Die mittlere Achse der beiden Polygone stellt die Schnittlinie dar mit den Stationen, in denen Ordinaten errichtet sind (schematisch in gleichen Abständen). Die Länge der Ordinaten entspricht der Fangmenge, ihre Unterteilung der Zusammensetzung derselben aus Altersgruppen. Der Übersichtlichkeit halber sind die I- und II-Gruppe nach unten, die älteren Gruppen nach oben abgetragen. Von den älteren Gruppen ist der Jahrgang 1922 in beiden Fällen auf allen Stationen der stärkste. Die einzelnen Jahrgänge sind in Fig. 5 A und 5 B durch die gleichen Symbole gekennzeichnet.

Es wäre sehr wertvoll, wenn wir einen ähnlichen Vergleich auch für das Gebiet vor der nordfriesischen Küste ziehen könnten, es fehlt aber leider das Material aus 1926. Als Indizium für das Hervortreten des

Fig. 5. Zusammensetzung der einzelnen Fänge vom Norderney-Schnitt aus Altersgruppen. Errechnete absolute Werte. A. September 1925. B. September 1926.

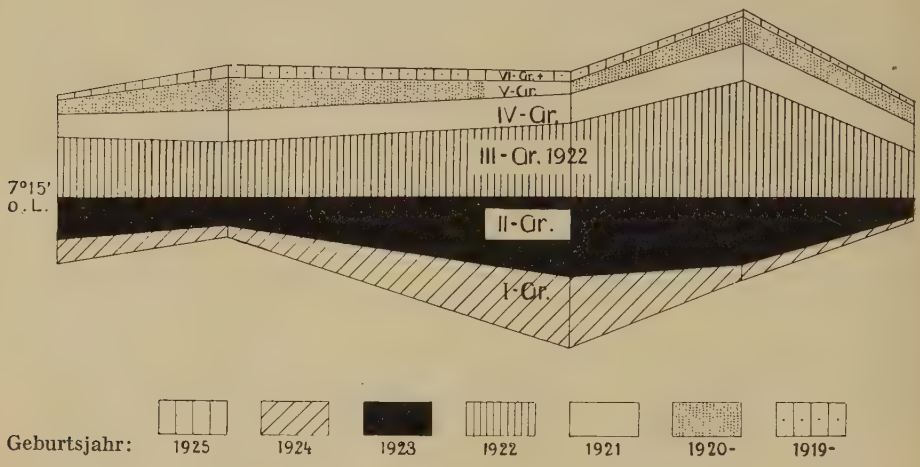


Fig. 5 A.

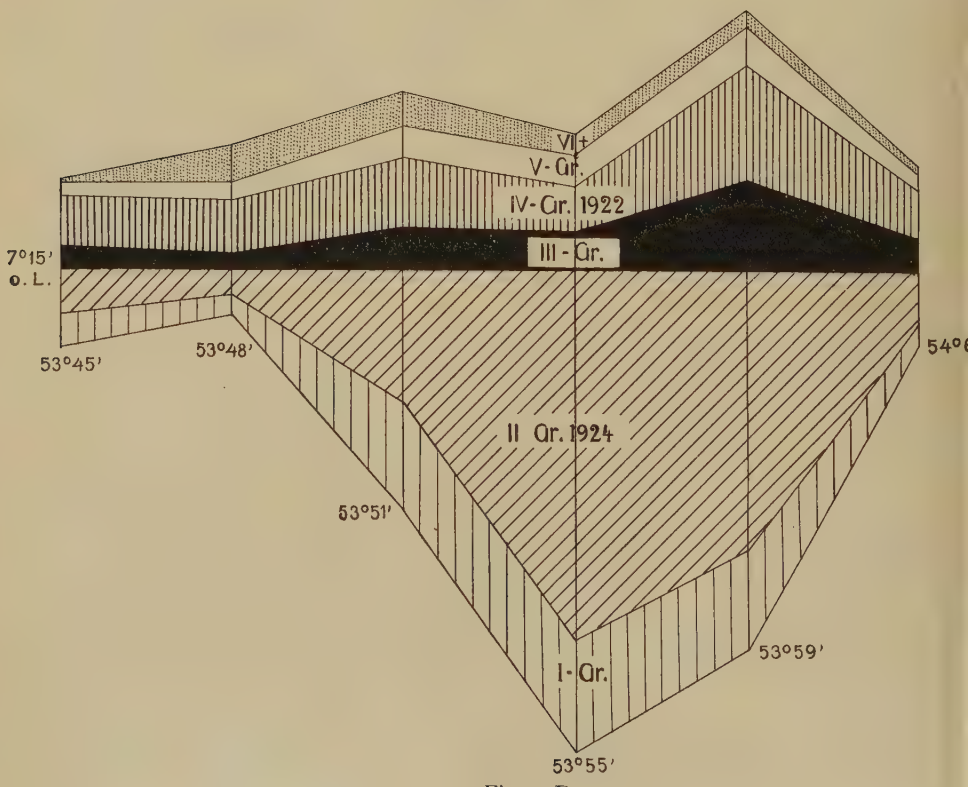


Fig. 5 B.

Die einzelnen Jahrgänge sind in Fig. 5 A und 5 B mit den gleichen Symbolen bezeichnet.

Jahrgangs 1922 können wir es allerdings ansehen, dass er auf dem Amrum-Bank-Schnitt im September 1925 überall, sowohl an der Küste wie im tieferen Wasser, den dichtesten Wert bildet, und die Altersgruppe II seinen Anteil nirgends auch nur annähernd erreicht. Ferner können wir es aus dem Vergleich von Fängen vom Sylt-Innengrunde aus dem März 1926 mit solchen aus einem Vorkriegsjahr entnehmen. Tabelle 4 führt das vergleichbare Material auf. Die Fänge sind in der gleichen Gegend gemacht, die von 1904 in etwas grösserer Tiefe.

Tabelle 4. Prozentuale Zusammensetzung der Otolithenproben aus Altersgruppen. Sylt-Innengrund, 10—20 m, März 1904 und 1926.

Untersuchungsjahr	I	II	III	IV	V	VI	VII	VIII +	Unters. Zahl
1904	13.5	70.3	15.9	0.3	—	—	—	—	995
Geburtsjahr...	1902	1901	1900	1899	1898	1897	1896	1895-	
1926	4.4	14.9	50.3	16.8	8.5	3.8	1.2	0.1	679
Geburtsjahr...	1924	1923	1922	1921	1920	1919	1918	1917-	

Während im Jahre 1904 auf die Altersgruppe II allein 70 % des Bestandes entfallen und die III-Gruppe nur 16 % umfasst, bildet 1926 der Jahrgang 1922 in der III-Gruppe (die neue Wachstumsperiode hat in beiden Fällen noch nicht begonnen) mit 50 % den dichtesten Wert, hinter dem die II-Gruppe mit nur 15 % erheblich zurücksteht. Interessant ist es, dass die älteren Jahrgänge 1904 fast gänzlich fehlen, während 1926 dieselben Altersgruppen, gebildet von den mehrfach erwähnten Kriegsbrutjahrgängen, noch in recht bedeutender relativer Menge auf diesem Küstengrunde vorhanden sind, vielleicht nicht allein wegen des grossen Reichtums dieser Jahrgänge sondern auch wegen ihres schlechten Wachstums.

Es fragt sich nun, ob dies verschiedentlich festgestellte Hervortreten des Jahrgangs 1922 darauf zurückzuführen ist, dass dieser Jahrgang besonders zahlreich ist, oder darauf, dass die mit ihm zusammen gefangenen anderen Jahrgänge besonders arm sind. Nach den Aufschlüssen, die das vorliegende Material liefert, möchte man annehmen, dass beides zusammenwirkt. Unzweifelhaft ist der Jahrgang 1923 sehr gering. In allen Zusammenstellungen tritt das sehr klar hervor, besonders in Tabelle 3, wo sich zeigt, dass er nicht allein als III-Gruppe von dem Jahrgang 1922, sondern auch als II-Gruppe von dem Jahrgang 1924

bei weitem übertroffen wird. (Über die Dichte des Jahrgangs 1924 lässt sich bisher noch nicht urteilen. Untersuchungen aus den nächsten beiden Jahren sind abzuwarten. Bei Helgoland erscheint er 1926 nicht besonders reich.) — Andererseits zeigt es sich auch, dass der Jahrgang 1922 in gleichem Alter einen grösseren Anteil des Bestandes ausmacht als Jahrgang 1921. Wenn nun auch der Jahrgang 1921 hinter denen von 1920 und 1919 an Dichte wohl zurücksteht, so erhält man doch nicht den Eindruck, dass er besonders gering sei. Tabelle 2 und 4 zeigen, dass er verglichen mit Vorkriegsjahrgängen in gleichen Gruppen durchaus nicht arm zu nennen ist. Da nun Jahrgang 1922 auch diesen überwiegt, ist es wahrscheinlich, dass er wirklich selbst zahlenmässig ungewöhnlich stark ist.

Es sei erwähnt, dass auch früher schon durch Heinckes Untersuchungen ein derartiges Vorwiegen einzelner Jahrgänge bei Helgoland beobachtet wurde, so im Herbst 1913 das Vorwiegen des Jahrganges 1910. Der Ausbruch des Krieges und anderweitige dringende Arbeiten machten es aber unmöglich, den Ablauf dieser Erscheinung rechtzeitig und bis zum Abschluss zu verfolgen. Über die Ursache solcher Ungleichmässigkeit der Jahrgänge kann man nicht eher urteilen, bis wir wissen, ob die gleichen Verhältnisse auch in anderen Teilen der Nordsee beobachtet werden konnten. Soviel sich übersehen lässt, ist es unwahrscheinlich, dass die Schwankungen der Befischungsintensität auf den Jungfischgründen diese Wirkung allein hervorgebracht haben. Es wäre zwar denkbar, dass bei plötzlicher sehr starker Verminderung der Fischerei hierdurch das Überwiegen eines jüngeren Jahrganges über einen älteren bewirkt würde, durch keine aber könnte das Überwiegen eines älteren über den jüngeren eintreten, wie es sich aus unseren Untersuchungen (1922 über 1923) ergibt. Eher ist anzunehmen, dass die Ursache tiefer liegt, nämlich in der verschiedenen Grösse der Jungfischerzeugung der einzelnen Jahre[1]). Es muss aber darauf hingewiesen werden, dass man nach allem, was wir über den Schollenbestand der Nordsee in den letzten Jahren wissen, wohl nicht annehmen darf, dass es noch die Nachwirkungen der Kriegsschonzeit sind, die die Laichproduktion des Jahres 1922 in günstigem Sinne wesentlich beeinflusst haben.

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[1]) Es sei hier erwähnt, dass Lübbert im Amerikahafen von Cuxhaven 1922 grössere Mengen kleiner Schollen fing als 1925 und, soweit beobachtet, auch als in den zwischenliegenden Jahren, sowie — nach persönlicher Mitteilung — auch als 1926. (Ber. Deutsch. wiss. Komm. N. F. Bd. II Heft 4 S. 53. Vergl. ferner die interessanten Beobachtungen Blegvad's (l. c.), der im nördlichen Kattegat ähnliches, im südlichen dagegen abweichendes Verhalten der einzelnen Jahrgänge feststellte.

Zusammenfassung.

Über das Auftreten natürlicher Schwankungen in der Menge des erzeugten Schollennachwuchses (Fluktuationen) wissen wir bisher noch sehr wenig. Es kann festgestellt werden (1.) durch quantitative Bestimmung der jährlich erzeugten planktonischen Eier und Larven, (2.) durch quantitative Bestimmung der jährlich vorhandene jüngsten Bodenstadien an der Küste, (3.) und in seinen Auswirkungen für den fischereilich nutzbaren Bestand am besten durch die quantitative Bestimmung der Alterszusammensetzung der älteren Schollenschwärme nach Jahrgängen. Der letzgenannten Möglichkeit dient das in dem vorliegenden Bericht gegebene Tatsachen-Material.

In der prozentualen Alterszusammensetzung von Schollenfängen aus der Deutschen Bucht (von Helgoland im Juli und September, von einem Schnitt von Norderney nordwärts im September und vom Sylt-Innengrunde im März) zeigt sich ein beträchtliches Vorwiegen des Jahrganges 1922. Ein Vergleich von Altersreihen der Nachkriegszeit (1922—1926) untereinander und mit solchen von Vorkriegsuntersuchungen (1904—1906) macht dieses Vorwiegen sehr deutlich. Es ist darauf zurückzuführen, dass der Jahrgang 1922 auf den Jungfischgründen ungewöhnlich reich, der von 1923 aber sehr arm ist. Die Ursache hierfür hat man wahrscheinlich in der verschiedenen Grösse der Nachwuchsproduktion dieser Jahre zu suchen. Um darüber mehr Klarheit gewinnen zu können, wäre es von grosser Bedeutung zu wissen. ob die Mitarbeiter der Internationalen Meeresforschung bei den Schollenuntersuchungen auch in anderen Teilen der Nordsee ähnliches beobachtet haben.

II. Size and Age Composition of the East Anglian Autumn Herring

by

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In the last report of the International Council (Rapports et Proc. Verb. Vol. XLI 1926) Mr. Einar Lea gave an account of the Norwegian Spring Herring Fishery and made suggestions for the prognostication of the stock of herrings for any year from the age composition of the shoals of the previous year. It was found from the age composition of the shoals

that there were two separate lots of fish which came together to form the great fishery of the West Coast in Spring. These were, firstly the older fish which had spawned previously, and secondly the "recruits" or first spawners — i. e. new stock.

The age composition of the older fish, the Large Herrings, was found to correspond closely with the age of the total stock of the previous year, after having made allowance for the 1-year increase in age. This return to the spawning grounds each year has made it possible, by methods described in the above paper, to estimate the age composition of the stock for the following year.

In the present paper I hope to contribute in a similar way to the knowledge of the stock of fish which forms the concentration south of Lat. 53° N, on which depends the East Anglian Herring Fishery in October and November.

The study of length and maturity of these herring began in 1922 and age records are available from 1923 onwards.

The fish caught during this fishing are, as I have pointed out in a previous report[1]), mainly "fulls" (Stage V of HJORT's scale), and while some of them spawn in the area, the majority do not spawn until December—January in other waters. They are, in this way, more comparable with the Large Herring of Norway than with the Spring Herrings.

There are, in the East Anglian Fishery, two classes of herrings, the "recruits" and the older fish but, unlike Norway, the recruits always appear in the early part of the season in the Smith's Knoll area. The older fish gradually make their appearance in the catches as the season progresses, as can be seen in Fig. 1 which shows the age of the samples of 1926 in chronological order.

For the purpose of observing the change in the composition of the stock in these waters, I have combined all the samples of each year into one large collection and then reduced the totals to percentages, this giving a qualitative picture of the fishery for each season.

Fig. 2 shows this total age composition for the years 1923—6.

The predominant ages in 1923 were 4, 5 and 8. As I have mentioned before [2]) it is not possible to say whether the fish with 8 zones on their scales belonged to a very rich 1915 year class, or whether the mode was artificially produced by "under fishing" in 1919 when they were four years old and appearing in the spawning shoals for the first time.

Whatever the cause of this mode may be, it serves as a guide post

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[1]) W. C. HODGSON: Fish. Invns. Ser. II, Vol. VIII, No. 5. 1925.

[2]) W. C. HODGSON: Fish. Invns. Ser. II, Vol. VII, No. 8. 1924.

in our first observations on the change of the East Anglian stock.

As with the Norwegian Herring, the movement of the modes one place to the right in each successive year suggests that there is an annual return of the old fish to the spawning shoals and a continual addition of new stock — the four year-old fish. The shape of the figure representing the old stock, it will be noticed, is remarkably similar in each year, so the rate of mortality seems to be approximately the same for all the year-classes over 5 years old. The year 1926 is noteworthy because of the large percentage of 5 year-old fish. Throughout the whole season these herring, from the spawning of the winter of 1921—2, predominated, and it is very probable that this year-class will prove to be a valuable addition to the stock during the next three years. It will be remembered that the Autumn fishery of 1921 was a failure, and now in 1926, from the spawning of that year we have the biggest incursion of "recruits" to the stock of the short series under review, these five year-old fish forming nearly 40 % of the samples examined.

From the commercial point of view the variation in the length of the herrings of the East Anglian Fishery is of more immediate importance than the variation in age.

In Figure 3 the lengths of the fish in each year from 1922 are shown. These are based on the total number of herrings measured in each season. In 1922 there were two distinct modes, one at 23—24 cms. and one at 26—27 cms. These lengths represent the

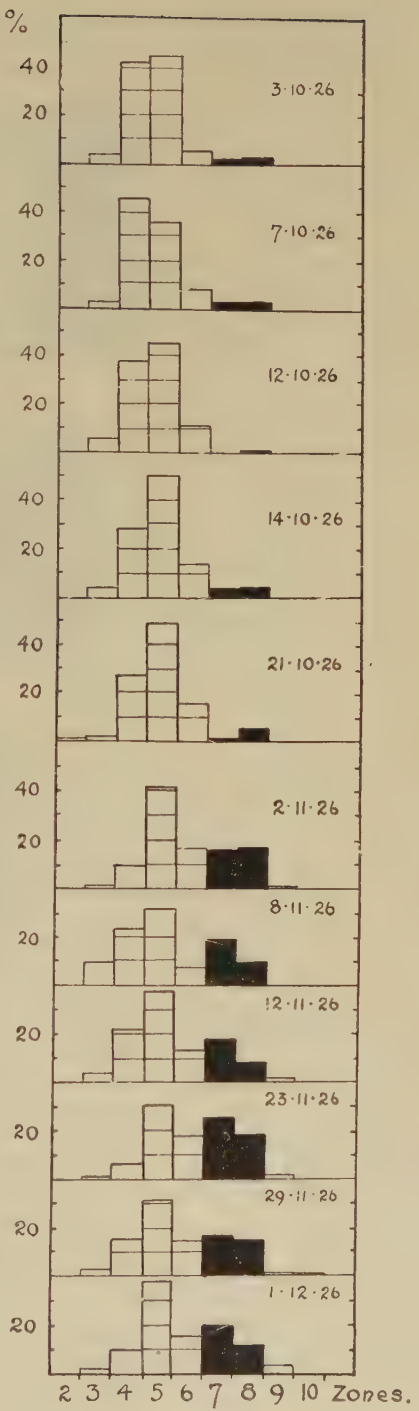

Fig. 1.

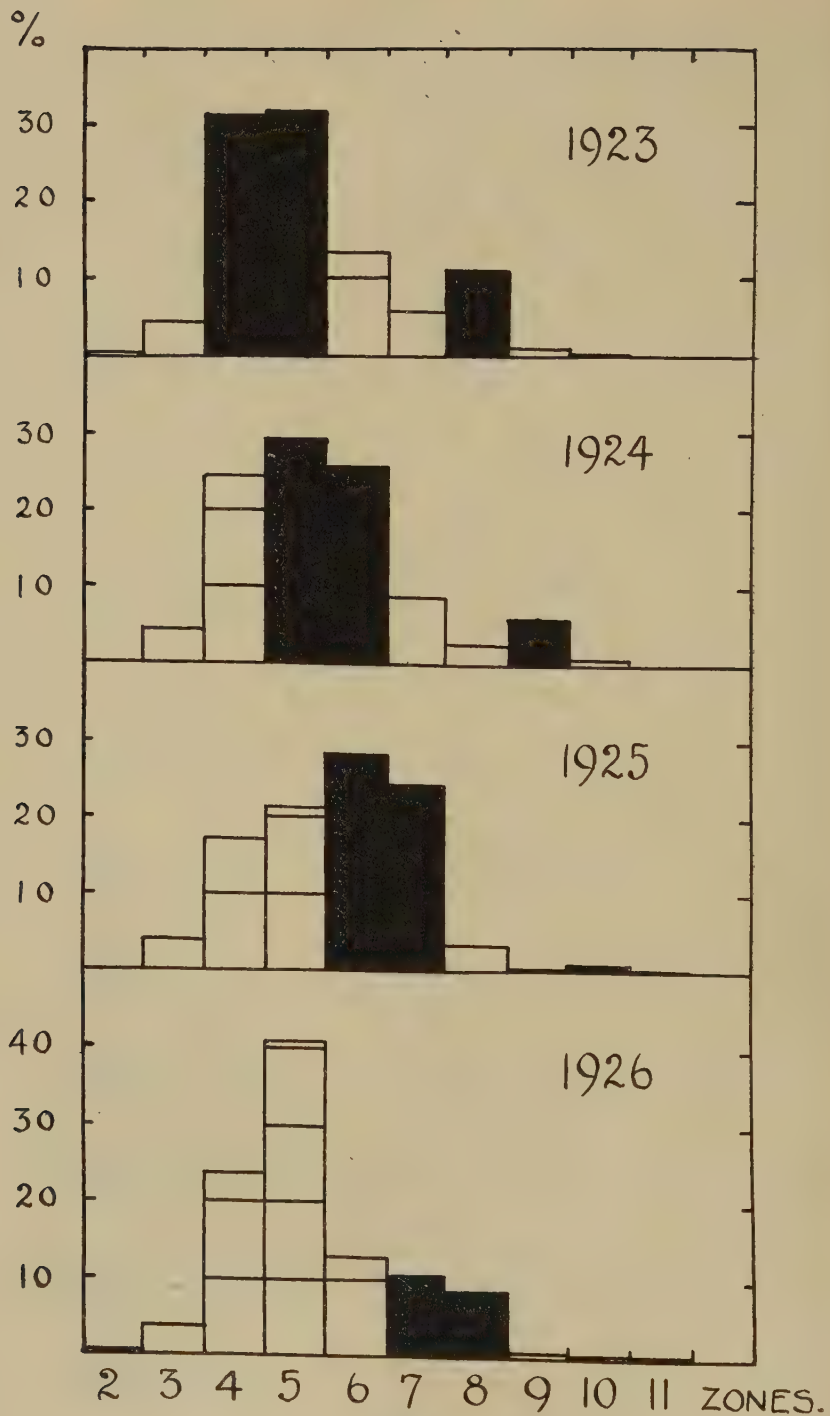
%
30
20
10
1923
30
20
10
1924
30
20
10
1925
40
30
20
10
1926
2 3 4 5 6 7 8 9 10 11 ZONES.

Fig. 2.

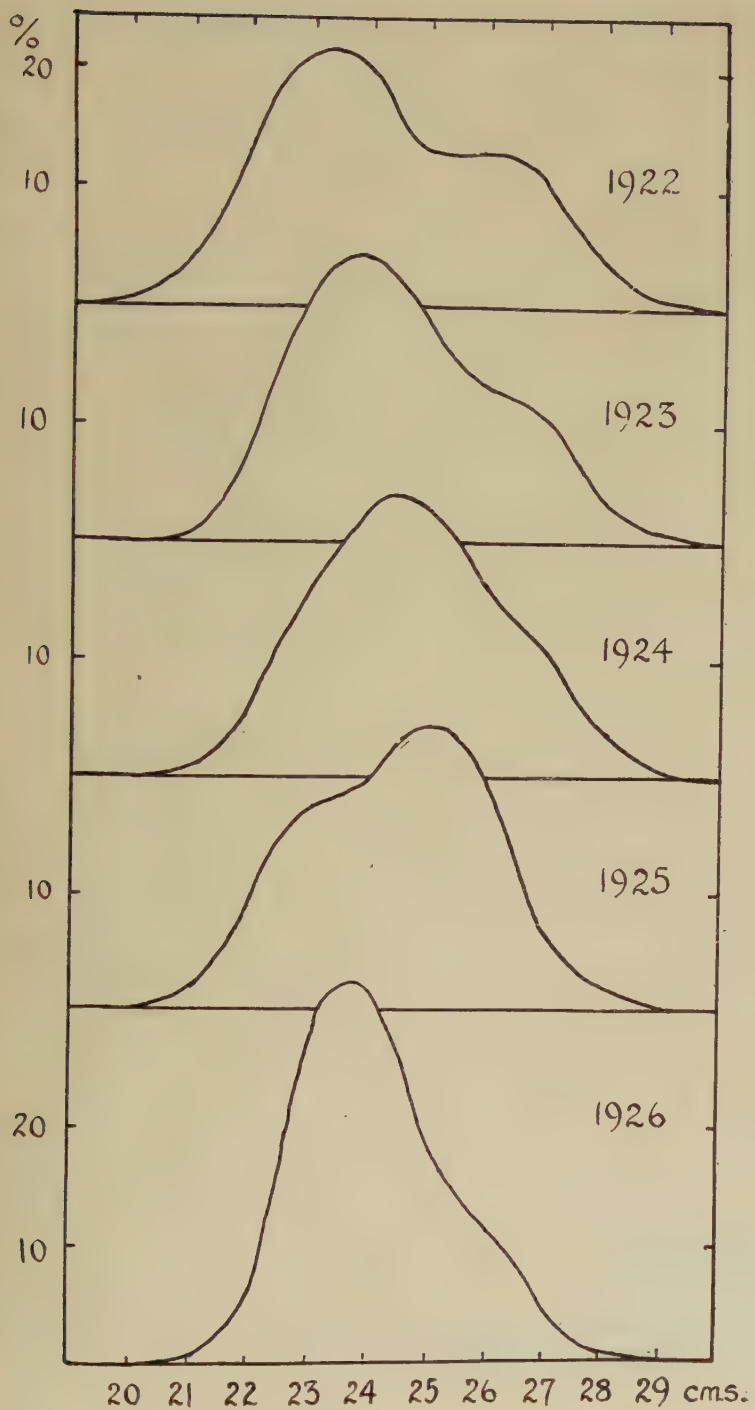
%
20
10
1922
10
1923
10
1924
10
1925
20
10
1926
20 21 22 23 24 25 26 27 28 29 cms.

Fig. 3.

"recruits" and the old stock. The growth of the fish which make up these modes can be followed in the figure as far as 1924, after which the mortality side of the curve flattens out, in agreement with the disappearance of the 1915 year-class (Fig. 2). Meanwhile, the "recruits" of the 1922 catches are still growing and in 1926 they cause a "hump" to appear at 26—27 cms.

From these curves we see that from 1922—5 the number of larger herring was gradually becoming less, until in 1926 their place appears to be taken by a new adult group.

The figure which represents the 1926 catches is very misleading in that it shows the larger herring to be a mere bend in the curve and numerically scarce compared with the younger group.

This, of course, is due to the fact that in the samples taken, the excess of those containing the young fish only has caused the older fish to appear in the summation in relatively smaller numbers, and thus give in no way a true picture of the actual stock (see Fig. 1).

The estimation of the stock, that is, the finding of the numerical relationship between the older fish and the "recruits" will be a task of considerable difficulty in the Southern Bight, if not an altogether impossible one.

In Norway, it is usual to find the two components of the stock isolated, and so it is possible to fix approximately the age composition of each day's catch of either lot of fish, the recruits or the older ones.

In the Southern North Sea conditions are much more complex. The younger fish are often caught apart from the older ones, but the latter are not caught until they come to the Smith's Knoll area and then they are more often mixed with the younger group. Again, the area fished on any given day may be a very extensive one, and some boats may land all small, all large, or a mixture of the two groups of herrings, so that the estimation of the composition of a day's landings would be impossible without ichthyometric records in such detail as to render the work entirely impracticable.

If Figures 2 and 3 represent the regular cycle of migrations to the spawning shoals it seems from the above that we must restrict any prognostications made, to qualitative ones only that is, we may foretell the ages and sizes, but not the proportion in which one age or size will appear in the catches.

But perhaps the main value of these four years of scale observations is to justify our application of the Norwegian Scale Theory and technique of scale-reading to the herrings of our own area.

Reviews.

Bjørn Helland-Hansen and Fridtjof Nansen. "The Eastern North Atlantic". The cruises of the "Armauer Hansen". No. 1. Geofysiske Publikasjoner, Vol. IV, No. 2. Oslo. 1926.

In the present paper an examination is made of material collected on the Norwegian expeditions into the North Atlantic undertaken as a continuation of the hydrographical investigation of the Norwegian Sea, together with any appropriate material obtained on other expeditions. This part is evidently the first of a series of such studies and constitutes a discussion principally of the salinity and temperature observations. An introduction to the work and a description of the several cruises which were made are given in Section I.

Section II describes the instruments and methods used. The water samples were collected by means of Nansen reversing bottles, 6 or 8 on a line at a time; each of these bottles carried frames for two reversing thermometers. The bottles appear to have operated remarkably well, except in a few instances at great depths.

The salinity was in all cases determined titrimetrically, though in some cases a specially constructed Löwe-Zeiss interferometer was used as well. The measurements made with this apparatus are stated to have been in good agreement with titrimetric determinations. All the samples were dealt with on shore, though preliminary determinations, which proved quite accurate, were sometimes made at sea both by titration and with the interferometer.

The observations from the cruises of the "Armauer Hansen" are tabulated together with the data used in the dynamic calculations. Many plans and sections carefully constructed to ensure the maximum of mutual correspondence are given showing salinity, temperature, density (σ_t), anomaly of salinity (see below) and contours of dynamic depths between isobaric surfaces (the standard surface in most instances being that of 2,000 decibars). Considerable evidence is brought forward in the course of the paper to show that at 2,000 metres the water movements were insignificant, in consequence of which the 2,000 decibar surface furnishes a suitable datum.

The conception of anomaly of salinity is an ingenious one and is derived from a relationship established between salinity and temperature — a method of research becoming widely used in Oceanography — at different depths in the North Atlantic. Low temperatures go with low salinities, and as temperature rises, the rate of change of salinity increases, though considerable departures occur, which are greatest at a temperature

of about 11° C. These departures are found to occur at depths of 1,000—1,200 metres in the south-eastern area of the region under investigation, where is found the greatest mixture with Mediterranean water. It is to be remarked, for example, that in a similar relationship set up for the waters of the Faeroe-Shetland Channel[1]) such departures do not appear.

Section III is devoted to a study of certain unusually high values of salinity which were found. Some of the samples giving abnormal values which were taken from great depths mainly in the south-eastern part of the region investigated, are abandoned by the authors as untrustworthy, on the assumption that the water bottles may not have worked satisfactorily. A certain system appears however in the distribution of these values, and when there was no reason to suspect the operation of the bottles, this leads to the opinion that the unusual conditions experienced were real. Occasionally water was found which was heavier than the water immediately beneath. Hence labile conditions must have existed, with the implication that there was no relative movement between the water strata. Moreover, in these instances, the limiting condition had not been reached in which an inversion occurs in the gradient of density taking compression into account (σ_t).

The possibility that vertical oscillations (Section IV) occur in the water layers, has been mentioned by the authors in previous works. The importance of having information about them is clear from the fact that they would, when they took place, manifest themselves as waves in the curves on the charts and sections. Such diagrams would not then truly represent the average conditions and it is pointed out that while the broader features depicted therein may remain unaffected, too much weight should not be attached to the details. The authors investigate this problem along two lines, first by studying the changes which occurred at two stations where the vertical series of observations were repeated at different times, and secondly by regarding the observations from lines of stations as a function of time rather than of space. In the first case the variations observed could have sprung either from a permanent sloping of the water layers or from vertical oscillations. The current velocities implied by such sloping being so great as to be unlikely, an explanation of the major part of these undulations in the curves is therefore to be sought in the presence of vertical oscillations, though vortices may sometimes have a share in their production. On this assumption, two types of periodic oscillation suggest themselves, diurnal and semi-diurnal. While scantiness of data precludes generalisation it appears that the diurnal period may prevail in the open sea and the semi-diurnal, at any rate in some layers, in the vicinity of banks and the continental shelf. In some cases the oscillations appear to have attained considerable amplitudes — e.g., more than 100 metres.

The vertical distribution of temperature is described in Section V and classified in two main types, northern and southern. The chief dif-

[1]) J. P. Jacobsen & A. J. C. Jensen: Cons. Perm. Int. pour l'Explor. de la Mer. Rap. et P. V. Vol. XXXIX. Report of the North-Western Area Committee for 1924 and 1925. page 51. Copenhagen 1926.

ferences between the types is to be found in the extent to which vertical mixing takes place in winter in the north, and the secondary maximum which occurs in the southern type at 1,200 metres — an explanation of which may be derived from an examination of the salinity anomalies, which point to the presence of Mediterranean water at this particular depth. It is also noteworthy that a relatively smaller positive anomaly is to be found at 1,000 metres at the northern stations as well, due to the same cause.

Section VI deals with the circulation of the water masses in the region of investigation as a whole. The direction of the stream lines and the current velocities at 100 metres (relative to those at 2,000 metres) are illustrated in Figure 14, while Figure 15 represents the main features of the general subsurface circulation. It is evident from the charts that the factor governing the current system at all depths is the North Atlantic Current, which, coming from the west, crosses the Longitudinal Ridge between 46° and 49° N. After bending towards the south, it divides abruptly into north-going and south-going branches. The former branch appears to be the major branch and flows towards Rockall where the bulk of the water is deflected and passes to the west and north-west of the bank. It is a continuation of this current which enters the Norwegian Sea.

The southern branch passes to the east of the Azores towards Madeira where it turns towards the north-east off the S.W. coast of Portugal; this branch in its turn divides, the main body of the stream turning southward.

The region lying between the continental shelf and the main currents appears to be occupied by two great vortices. The southern cyclonic system is governed by the southern branch of the North Atlantic Current, and the northern anticyclonic system by the northern branch, though below 600 metres the anticyclonic system seems to be fed by a current from the south, since traces of Mediterranean water are carried as far north as the Rockall Channel, and beyond. Both these systems seem to reach their greatest development in the upper layers; at 1,200 metres they are barely appreciable.

On the whole there is a general correspondence between the distribution of salinity and temperature, and the current system outlined. An interesting point arises from a comparison of the isopycnals and isobaric contours in the central region, namely, that in the upper layers the heavier water lies on the right hand side of the stream lines, from which it follows that the current velocities increased downwards, a condition due perhaps to the retarding influence of the northerly winds then prevalent. The maximal velocities seem to occur at 800 metres. In this connection it is interesting to recall that the charts of surface currents, mainly determined from the observed set of ships, show (especially in June and July when northerly winds prevail) a predominantly southerly set in the region west of Portugal.

Considering the distribution of salinity and temperature, the two features which most impress themselves are the presence of Mediterranean water between 600 and 1,400 metres, with a maximum distribution at 1,200 metres, and the arrangement of the isohalines and isotherms in

two distinct belts at certain levels. This latter feature appears to be due to the peculiar way in which the mixed Mediterranean water extends itself westward in the region where the cyclonic and anticyclonic systems predominate.

The water below 2,000 metres is shown to be of even distribution with salinity of about 34.9 $^0/_{00}$ and temperature of about 3° C., and as before mentioned, the water movements may be regarded as insignificant.

In the concluding Section VII a discussion is given of the few current measurements made at two stations, one series from an anchored boat on the Rockall Bank and the other from the ship drifting off the Portuguese coast. Portions of rotatory tidal movements seem to have been observed at various depths, *cum sole* on the Rockall Bank and *contra solem* off Portugal, where there was a further indication that between 5 and 1,000 metres the water moved mainly in a northerly direction.

J. R. L.

V. Walfrid Ekman. On a new repeating current-meter. Publ. de Circ. No. 91 (June 1926).

To Prof. V. Ekman belongs undoubtedly the merit of having furnished oceanography with some of its most efficient instruments. His earlier current meter has proved very efficient and useful within the limits given for an instrument designed for single observations of short duration and it is probably the most widely used current meter. Although quite a number of instruments exist for measuring currents in the upper water layers, there still remains the problem of measuring the generally slow currents of the deep sea. There is of course the indirect method by calculating from the distribution of densities, but it is something of an open question whether the general application of this method is quite justified when regard is paid to the nature of the material available from the deep ocean, unsatisfactory both in point of quantity and comparability. The method would in any case profit immensely by being tested against actual measurements of a trustworthy nature.

The author reviews the different methods imagined or tried to measure currents in deep water and concludes his survey by assuming that no method hitherto devised is likely to give trustworthy and undebatable results. Accordingly he set out to construct the new instrument which is described very lucidly in the paper under review. The new instrument presents a number of novel and ingenious features, making a study of the description very interesting: the messengers which divide into three pieces and fall into a receptacle when their "mission" is fulfilled and thus give room for the next one, the registration of propeller revolutions performed by two numbered balls falling into two chambered receptacles which are moved at a rate of 10:11 relatively to each other, the well thought-out contrivances for recording the results.

The possibilities of the instrument are to permit up to 47 consecutive observations at any depth a ship can be anchored in, at any intervals desired (down to a few seconds), and with current velocities down to 2 or 3 cm. per second, possibly even only 1 cm. per second (= 0,02 miles

per hour). The record is in the form of the number of revolutions during the interval between the release of any two messengers. (In depths less than 3 or 4 hundred meters the actual hitting of the messengers may be recorded, although this is not of great importance as the running speed of the messengers has been found to be very constant, lying between 53.8 and 55 secs. per 200 m., thus creating an uncertainty as to the length of periods in 1000 meters of only about 10 or 12 secs.).

The most serious limitation of the instrument lies in the fact that the speed is recorded as a sum of revolutions covering the whole interval, while the record of direction applies only to the last moment of the interval, i.e. the moment when the messenger hits the arm releasing the spring-wheel, but this limitation is, of course, less important the shorter the intervals are made.

The instrument has been used during two summers (1923, 1924) in the Faroe-Shetland channel, at various points in the northern North-Sea and along the edge of the continental shelf from the latitude of Shetland to that of Cape Stat, on board the "Armauer Hansen", the "Johan Hjort" being employed at the same time in making oceanographical observations in such a manner as to provide material for a comparison of the currents calculated and those actually observed. During this work the reviewer had often an opportunity to observe the working of the current meter and satisfied himself as to the reliability of its functioning and the apparent consistency of the records. Some of the measurements were made when anchored in up to 1,600 meters depth, the movements of the vessel being as far as possible recorded by taking the magnetic bearing and the inclination of the anchoring wire every minute. As the results of this work are not yet published, it is too early to form a judgment of its success, but there is every reason to believe that they will prove valuable and interesting, being the first seemingly successful attempt to measure slow currents in very deep water. OSCAR SUND.

H. U. SVERDRUP and O. DAHL. Two new recording Current Meters. (Two oceanographic Current-Recorders designed and used on the "Maud" Expedition, Journal of the Optical Society of America and Review of Scientific Instruments. Vol. 12. No. 5. May 1925).

It is a feat worthy of admiration that the scientist in charge of the observations during the "Maud" expedition, with the assistance of one of his fellows, designed, constructed and kept in operation for long periods a new current meter (made in two types) which seems to solve the greater number of difficulties attending this kind of observations. When one considers the absolute isolation of the workshop of the "Maud" and the success attained, there is every reason to congratulate Prof. SVERDRUP and Mr. DAHL on their achievement.

The two types of current meters differ in the way the direction is got, one model being hung on a bifilar frame, for moderate depths, the direction of the frame being recorded independently, the other model being provided with a compass needle. Otherwise the construction is very much the same.

These current meters contain two ingenious, and, as far as known, novel features: 1) the registering of direction by inserting an ampère meter in an electrical circuit (one branch being insulated, the other provided by the supension cable), which is closed every time a certain number of revolutions are completed by the propeller, and 2) the use of a "diving bell" to provide a dry space for the magnet needle and the electrical contacts. The air in this chamber is protected against absorption by the water under pressure by a small quantity of petroleum let into the bell before immersion.

In the bifilar type the direction is registered by a key being brought into contact with one of 18 segments (each of 20°) constituting a resistance ring. In the compass type the compass needle itself is used as "key", being slowly let down on the resistance ring by an eccentric wheel acting on the lower end of the pin every time the propeller has turned 80 times, and the circuit remains closed during 20 turns.

The constants of the instruments were obtained by direct experiment and by comparison with Ekman's (single observation) current meter. The lower limit of velocities reliably recorded was 4—5 cm./sec. in the case of the bifilar type as against ca. 3 cm./sec. by the Ekman instrument, but Prof. Sverdrup maintains that this limit may be reduced when his instrument is made of better materials than those available to him. The compass type was found to be reliable down to between 5 and 6 cm./sec., but this also it should be found possible to reduce.

In both instruments the cable used was 1.5 square millimeter okonite cable. The bifilar instrument was kept in operation for 14 months, suspended through a hole in the ice, using 24 hour record paper. The other was not used for any long periods, but was always found to work very satisfactorily during numerous experiments. Prof. Sverdrup believes that it will work at any depth, even thousands of meters, especially if a cable be used which contains both the suspension element and the insulated wire. Both instruments seem to be comparatively cheap to construct. A very important advantage of the Sverdrup current meter is that the working of the instrument can be watched at pleasure, the recording mechanism being placed safe and dry in a ship's saloon, or in a hut on the ice, as the case may be.

Oscar Sund.

R. Southern and A. C. Gardiner. The Seasonal Distribution of the Crustacea of the Plankton in Lough Derg and the River Shannon. Saorstat Eireann (Irish Free State). Department of Fisheries. Scientific Investigations. 1926. No. 1. 1926.

In der vorliegenden Arbeit berichten die Verfasser sehr ausführlich über ihre 1920—1923 in einigen irischen Gewässern angestellten Plankton-Untersuchungen. Diese Untersuchungen wurden ausgeführt in der damaligen schwimmenden Station[1]) der irischen Fischereiverwaltung unweit Portumna in einem nicht schiffbaren Kanal am östlichen (Tipperary-)

[1]) Die Station ist inzwischen aufgehoben.

Ufer des Shannons. Die Hauptaufgabe dieser Station war: die unentbehrlichen naturwissenschaftlichen Grundlagen für die künftige Regulierung und Hebung der Binnenfischerei zu beschaffen, und die vorliegende Arbeit enthält nun zunächst und hauptsächlich Angaben über die planktonischen Crustaceen des Shannons und des benachbarten Lough Derg. Dieser See ist der letzte und südlichste der Shannon Seen, liegt 108 Fuss über dem Meeresspiegel und hat ein Areal von 50 Quadrat-Meilen. Der nördliche Teil ist nicht sehr tief, bis etwa 20 Fuss, der südliche ist jedoch bedeutend tiefer, an einzelnen Stellen bis 119 Fuss.

Ausführliche Angaben über die Geologie des Shannonbeckens sowie über meteorologische und limnologische Beobachtungen werden vorangeschickt. Der CaO-Gehalt des Sees war ziemlich hoch (139 mgr/l), er gehört somit zu Naumann's Polytypus. Der Cl-Gehalt ist gering (14 mgr/l), der totale Salzgehalt etwa 264 mgr/l. Die Wasserstoffionen-Konzentration (pH) schwankte zwischen 8 und 8.4 in L. Derg, im Shannon R. war sie etwas niedriger (7.8—8.3). Ueber ihre Bedeutung für die Lebensverhältnisse des Planktons äussern sich die Autoren nicht, weil eben noch zu wenig Vergleichmaterial vorliegt.

Einen wichtigen Abschnitt bilden die Angaben über die bei den Plankton-Untersuchungen angewandte Methodik. Das Material wurde nicht nur mit den üblichen Vertikalnetzen, Planktonpumpe und Centrifuge eingesammelt, sondern auch mittels sorgfältig ausgeführten quantitativen Horizontalfängen, wobei an jeder Station sowohl an der Oberfläche wie über dem Boden gefischt und die jedesmal erhaltene Individuenzahl gemittelt wurde. Diese Methode ergab in dem verhältnismässig untiefen Wasser recht brauchbare Resultate. Für Einzelheiten sei auf das Original hingewiesen.

Die vorliegende Abhandlung befasst sich nun fast ausschliesslich mit der jahreszeitlichen Verbreitung der Crustaceen im nördlichen Teil des Gebiets. Ausserdem wird einiges über das Phytoplankton mitgeteilt.

Auffallend war die relative Armut an Desmidiaceen, das starke Ueberwiegen der Diatomeen im Frühling und Sommer sowie das Vorherrschen der Myxophyceen (besonders *Oscillatoria agardhi*) im Herbst. Auffallend sind auch die geringen Zahlen für Chlorophyceen und Flagellaten. *Rhizosolenia longiseta* wurde im Sommer beobachtet. *Attheya* und *Coscinodiscus* scheinen jedoch zu fehlen.

Als häufigste Rotatorien werden die in aller Welt vorkommenden Planktonformen genannt, ausserdem einige litorale Arten, *Pedalion mirum* wird nicht aufgeführt. Die Rotatorien ernähren sich reichlich mit Planktondiatomeen, sogar mit verhältnismässig grossen Arten, welche nur selten von den Entomostraken genommen werden.

Die Zahl der beobachteten Crustaceen ist recht gross, doch werden auch hier viele litorale resp. am Boden lebende Arten erwähnt. *Daphne longispina* ist weitaus die häufigste von allen Crustaceen, zu gewissen Zeiten bilden jedoch *Bosmina coregoni* und *Leptodora kindti* zusammen mit *Diaptomus gracilis* den Hauptbestand. Auch *Bythotrephes longimanus* gehört zu den häufigeren Arten, *Diaphanosoma brachyurum* und Ceriodaphnien sind jedoch merkwürdigerweise recht selten. Von den Copepoden sind ausser *Diaptomus* nur *Eurytemora velox* und *Cyclops strenuus*

häufiger. Es wäre interessant nach zu prüfen, ob die als *C. strenuus* Fischer aufgeführte Art vielleicht nicht doch die nahe verwandte *C. vicinus* Ulj. ist, welche in den vom Referent untersuchten Gewässern überall planktonisch lebt, während *C. strenuus* sich mehr in kleinen Gräben aufhält. Die Verfasser scheinen die diesbezügliche Arbeit von Frl. de Lint nicht zu kennen.

Als einzige Schizopode wird *Mysis relicta* erwähnt.

An die Erörterungen über die Verbreitung der Crustaceen schliessen sich einige Kapitel über die Periodizität des Planktons, über den Einfluss des Shannon-Flusses auf das Seenplankton, sowie über die Wirkung des Windes auf dessen horizontale Verbreitung an. Einige Arten, besonders *Daphne*, scheinen sehr empfindlich zu sein gegen den Schlamm, der bei Zeiten, wenn die "braune Flut" (brown flood) im Shannon auftritt, dem Lough Derg zugeführt wird. Andere Arten (*Leptodora*, *Diaptomus*) zeigten sich dagegen weniger empfindlich.

Die Beobachtungen über die Nahrung der Entomostraken bestätigen die Ansichten Naumann's über die Bedeutung des staubfeinen Detritus als Nahrungsquelle.

Schliesslich wurde die Bedeutung der Planktonkruster als Fischnahrung untersucht. Die Brut von Barsch, Hecht, Schleihe, Rotfeder und Brachsen lebt fast ausschliesslich davon, doch es werden vorwiegend Cladoceren (*Bosmina coregoni* und *longirostris*, *Ceriodaphnia pulchella* und einige andere) gefressen, *Cyclops* nur selten und *Diaptomus*, obgleich er nicht selten ist, überhaupt nicht, eine Beobachtung, welche auch wiederholt von mir gemacht wurde. Die Wachstumsgeschwindigkeit der Barschbrut hängt von der Crustaceenmenge ab. Von den erwachsenen Fischen ernährt sich der "Pollan", *Coregonus elegans*, fast ausschliesslich mit Planktoncrustaceen (*Daphne*). Dieselben sollen auch, wenn sie recht zahlreich sind, die Hauptnahrung vieler erwachsener Barsche und Forellen bilden.

H. C. R.

F. S. Russell. The Vertical Distribution of Marine Macroplankton. III. Diurnal Observations on the Pelagic Young of Teleostean Fishes in the Plymouth Area. Journal of the Marine Biological Association of the U. K., N. S., XIV, pp. 387—414 (1926).

In a recent paper in the Journal of the Marine Biological Association Mr. Russell described the vertical distribution of the invertebrate plankton taken in a series of hauls made off Plymouth during the hours of light and darkness at five different depths, determined by a depth recorder, with a stramin ring trawl. He now deals with the post larval fishes taken on that occasion, supplemented by a second series of hauls made at six different depths, repeated at intervals from the afternoon of June 17th to the morning of June 19th 1925. The difficulty of telling beforehand at what depth the net would fish and the fear of risking the loss of gear prevented the lowest haul from being made as close to the bottom as was desirable. In one attempt to reach as low as possible the net struck the bottom, and efforts to avoid the recurrance of this mishap resulted in leaving the lower two fifths of the depth unfished and consequently in

many instances prevented definite conclusions from being arrived at. Another disappointing feature, after the expense of so much labour in making and sorting the collections, was that, although a very large number of young fishes were taken, in one haul amounting to 1600, they consisted mainly of young Pilchards and either *Gobius elongatus* or *Callionymus* sp., and the remainder were divided up amongst so many species that seldom was there enough of one species to show its movements clearly.

The results obtained did not, except in the case of *Sardina pilchardus*, indicate any marked upward movement at night. For some species, e.g. *Gadus minutus*, *Scophthalmus norvegicus*, *Pleuronectes microcephalus*, *Solea variegata*, *Arnoglossus* sp. and *Trigla* sp. there was evidence that a small proportion of the population moved into the upper layers by night. In other cases e.g. *Gadus merlangus*, *Caranx trachurus*, *Scomber*, *Lepadogaster* and *Labrus*, the evidence was not in favour of any such movement, and for a good many species there was not sufficient evidence to give any indication of how they reacted.

Sardina pilchardus, *Callionymus* and *Gobius elongatus*, of which larger numbers were taken, allow of more full discussion. The Pilchard, with a tendency to be most plentiful between 10 and 20 metres by day, filled up the surface layers at dusk and midnight, descending again at dawn. A decision as to what actually did occur is rendered difficult by the fact that at all depths the young Pilchards, not more than 20 mm. in length, were about ten times more abundant during the hours of darkness than during the day. The author discusses the possibility of swarms having been met with or of the fish avoiding the net by day but does not commit himself to any theory. *Callionymus* and *Gobius elongatus* also showed the same phenomenon of increased numbers by night, with a relative increase in the upper layers, but in a lesser degree, but only in the 1925 experiments, when there was no moon, and not in 1924, when the moon was full.

Taking the records as a whole the reaction to darkness on the part of post larval fish seems vague and ill-defined. The author however seems to see indications that strong light may provide a more powerful stimulus, but for the elucidation of this we must await a fresh series of hauls through the hours of daylight, including some if possible near the bottom.

G. P. F.

F. S. Russell. The Vertical Distribution of Marine Macroplankton. IV. The Apparent Importance of Light Intensity as a Controlling Factor in the Behaviour of Certain Species in the Plymouth Area. Journal of the Marine Biological Association of the U. K., N. S., XIV, pp. 415—440, (1926).

Mr. Russell here puts forward for consideration some of the conclusions or theories to which he has been led by the study of vertical distribution as disclosed by horizontal plankton hauls at successive depths.

In the first place he points out that the intensity of light in the sea decreases in clear water not in direct proportion to the depth but in geometrical progression. Thus if the surface light intensity were halved at 5 metres, at 10 metres it would again be halved and at 15 meters would

only amount to one-eighth of the surface intensity. Taking as an instance the penetration of light actually observed by Poole and Atkins off Plymouth, which does not differ materially from the example taken above, he shows that if we assume that for a certain animal there is an optimum light intensity and a maximum and a minimum limit of toleration, each differing from the optimum by an equal number of light units, the minimum limit will be much further below the optimum than the maximum is above it, or, assuming an animal with an optimum light intensity of 35 units and a range of 65 units, the optimum, taking the surface intensity as 100 units, will be found at a depth of about 7.5 metres, the maximum limit being just over 5 metres above it, i.e. at about 2 metres and the minimum limit 19 metres below it at about 26.5 metres. This distribution can be represented graphically by a kite shaped figure which theoretically will show the same dimensions at whatever depth the optimum light intensity is found. The smaller the ratio $\frac{\text{range}}{\text{optimum}}$ becomes the more nearly equal will be the distances between the optimum and the upper and lower limits of the range.

It is pointed out that several plankton animals assume at times a type of distribution corresponding more or less closely to this theoretical type, notably *Calanus finmarchicus*, in which a high light intensity optimum is combined with a large range of tolerance, and *Cosmetira pilosella* with a much lower intensity optimum and, under some circumstances at any rate, a much smaller range. Diagrams of the observed daylight vertical distribution of these two species at different seasons of the year are given.

The author guards against asserting that there is any reason in nature why the optimum should lie exactly midway, in light intensity units, between the maximum and minimum. He seems hardly, however, to insist sufficiently on the point which be brings out that in waters of uniform transparency, if the distribution is conditioned by the light intensity, the range above and below the optimum will remain practically unaltered whatever the depth of the latter may be.

The next point considered is the depths at which at different seasons of the year equal intensities of light may be found, and a table and diagram have been constructed showing these depths for the waters off Plymouth. The observed depth of the optimum for *Calanus finmarchicus* showed a corresponding gradual descent from April to June followed by a rise to August, the discrepancies noticed being correlated with observed variations in the overhead lighting. The optimum for *Cosmetira* did not follow so closely the estimated depth curve for low light intensity but in this case the presence of abundant plant life, Diatoms and Phaeocystis, furnished a possible explanation.

The reactions of various animals to the light variations from day to night are also briefly discussed but although a more or less definite response is evident in the three species considered, *Calanus*, *Turris* and *Cosmetira*, it is clear that, as the author remarks, more observations must be made before the true significance of these changes becomes apparent.

The possible effects of temperature, turbidity and varying quality of

light are also referred to, and the conclusion that light intensity is the external factor of the greatest importance in determining the vertical distribution of the plankton in the region under observation seems to be fully justified. G. P. F.

M. V. Lebour. A general survey of larval Euphausiids, with a scheme for their identification. Journal of the Marine Biological Association of the U. K., N. S., XIV, pp. 519—527, (1926).

In this paper Dr. Lebour gives a convenient summary of the general course of development which characterises the Euphausiidae and which she has done so much to elucidate. To the egg succeed two nauplii and a meta nauplius followed by three Calyptopis stages, in which the carapace covers the eyes, and a varying number of Furcilia stages, with eyes uncovered and successively developing pleopods, and finally the Cyrtopia, in which the antenna, previously used for swimming, develops an antennal scale and flagellum and the general form of the adult is assumed. The different developmental stages which have been described in the seven genera whose development has been studied are briefly set out. Of the three remaining genera in the group practically nothing is known. The successive changes which make up the Furcilia stage are given in greater detail, the known stages which may occur, from that with five segments without pleopods to that in which five setose pleopods have been developed, being numbered 1 to 14, but of these several are alternative and not successive. It is suggested by the author that the earlier stages with, successively, 1, 2, 3 and 4 simple pleopods and the later stages with five pleopods, of which 2, 3, 4 and 5 successively become biramous and setose, are common to all genera (except Stylocheiron in which the 1st pleopod becomes setose before the 4th appears) and that the intermediate stages by which the four simple pleopods develop into two setose and three simple ones vary in different genera in a characteristic manner. On this basis a key has been constructed by which when the characteristic Furcilia stage or stages are met with the genus to which they belong may be determined.

An obvious erratum occurs on pp. 524 and 525 where the fourth Furcilia stage of Stylocheiron is referred to as "Furcilia 5" instead of "Furcilia 7". G. P. F.

Anon. Fluctuations in the Herring Fisheries. Fish Trades Gazette. London. Oct. 23rd, 1926.

An anonymous article bearing the above title appeared recently in the Fish Trades Gazette. The present writer has found the paper interesting and the following summary is intended to give other workers some idea of the scope of the article.

A brief and comprehensive description of the work done by Norwegian investigators introduces the subject. The data relating to the presence

of the 1904 year-class in the catches of fat, large and spring herrings illustrate not only the active migrations of the fish after they are three years old but also the importance of a good year-class and the effect it may have on the yield from a fishery over a number of years. That fluctuations in a fishery do not vary with the wealth of year-classes and that other factors must be considered is well illustrated by the catches of fat herring for Nordland and the whole of Norway, and the yield from shoals of spring herrings.

A consideration of the fluctuations in the Loch Fyne fishery follows a brief account of the seasons of the British herring fisheries. Statistics showing the yield of the fishery from 1854 to 1925 are given, and attention is drawn to the fact that good and bad years come together in groups. As well as fluctuations in the yield there are variations in the size of the fish caught, the extent to which the herrings penetrate the Loch, and the monthly catches. The latter point to the possibility of there being some agreement between the total catch for the year and those made in the early part of the fishery.

The catches of herrings in Scotland from the year 1892 to 1925 are given, and as well as the totals for the year we have the yield for the East Coast, Orkneys and Shetlands, and the West Coast. The figures for the Great Summer and Autumn fishery are given in a separate column. Data are given for the catches from the East, South, and West Coasts of England and Wales from 1895 to 1925. The figures emphasise the enormous fluctuations which have occurred.

Attention is drawn to the importance of appreciating the difference between fluctuations in the yield from the fisheries and the abundance of herrings in the sea. Fluctuations in yield may be brought about by economic causes. It is thought that the extent of natural fluctuations would be understood better were information published as to the number of vessels fishing, the average catches, fishing grounds, and possibly the number of nets used.

The part played by winds and currents on the distribution of the young herring and its food, and the possibility of the future stock of the fishery being determined by variations in these agencies is indicated by a brief but telling account of some of the hydrographic and biological researches. The work of Dr. T. Wemyss Fulton, begun in 1894, gave us a fundamental idea as to the circulation of the surface waters of the North Sea and this has been added to considerably by Mr. J. N. Carruthers in recent years. Mr. Hardy and Dr. Marie Lebour have given a comprehensive account of the food of the herring. Dr. Wallace has shown how the young from different spawning grounds may be mingled together in the Thames estuary and how variations in winds and currents may effect the mixing of the young fish.

Then follows a consideration of the action of winds and currents and their probable bearing on some of the fluctuations in the herring fishery.

In the winter 1896—97 there was a reversal of surface currents in the North Sea brought about by the prevailing winds in December and January blowing steadily from the south and east. As a great body of water cannot be removed from the North Sea without Atlantic water taking its place

it is thought that, had hydrographic and biological researches been carried on at the time the presence of unusual quantities of Atlantic water in the northern North Sea would have been revealed. Following the reversal of currents there was in 1897 a decrease in catches from the East Coast amounting to about 47 per cent., a successful fishery in the Moray Firth district, and increased catches from the Orkneys, Shetlands and West Coast. In 1898 catches were higher on the East Coast. A northerly drift of young fish which would carry them out of the North Sea during the reversal of the currents might account for the poor fisheries on the East Coast in 1899 and 1900 and an extraordinary abundance of herrings in Shetland waters.

Following the year 1904, which gave the rich year-class of herrings in the fisheries of Norway and Newfoundland, those of haddock and cod of the North Sea, and cod in Norwegian waters, there was an invasion of Atlantic water in 1905 when the north-west part of the North Sea was flooded with warm Atlantic water and there was a December air temperature the highest for 35 years. In 1905 the Shetland herring fishery was the highest on record. That of the East Coast was low but this was probably due to vessels staying longer in Shetland waters where the fishing was good. Yarmouth autumn fishery was prosperous. The Dutch North Sea fishery was poor. The catches on the east coasts of England and Scotland were greater in 1906 than in 1905.

Two explanations are put forward for the marked fluctuations in post-war years — the effect of the war-closure and the great influx of Atlantic water. The reasons for the first explanation are advanced but it is evident that Atlantic water is considered the determining factor. In 1920 Atlantic water, bringing with it enormous numbers of salps, invaded the North Sea. These in 1921 had penetrated as far south as the west edge of the Dogger Bank. During the winter 1920—21 there was a reversal of the normal North Sea currents which coincided with a prevalence of southerly winds. An abundance of herrings on the Fladen Grounds, just beyond the eastern boundary of the salp invasion, marked the year 1920. In the following years 1921—23 the catches for the east coasts of England and Scotland were at their worst.

Attention is drawn to a further invasion of salps in 1925.

In a consideration of the possible prediction of herring fisheries the infinite complexity of the problem of fluctuations is indicated. Recent literature convinces the author that researches at present being conducted are admirable in plan, scope and execution. The greatest confidence is expressed that further reports will add to our knowledge of fluctuations in the herring and other important fisheries. An improvement in statistics to show for each fishery the seasonal catch in relation to the amount of fishing, annual drift-bottle experiments, and an examination of wind records are asked for.

In a concluding paragraph reference is made to the matter of marking herrings. The difficulties of such experiments are well recognised. It is suggested that the mark, or tag, should have two hooks, one of which is to be attached to the fish and the other to be caught in the net and thus compel the fishermen to handle the marked herring. B. Storrow.

C. Tate Regan. The Pediculate Fishes of the Suborder Ceratioidea. The Danish "Dana" Expeditions 1920—22 in the North Atlantic and the Gulf of Panama. Oceanographical Reports, No. 2, Copenhagen and London, 1926.

This report is excellently got up, the drawings are remarkable for their clearness and skill in presentation, and a mass of information has been collected and sifted which should at some future date prove of the greatest assistance to future investigators. Apart from the osteology and classification of the fishes of this suborder, Mr. Tate Regan devotes a special section to the "dwarfed males" of the Ceratioids, and there is no doubt that this section is the most interesting and probably the most important of all.

The Ceratioids, according to Mr. Tate Regan, are unique among Vertebrates in that the males are dwarfed and parasitic upon the females. There are three species in which the males are known, *Photocorynus spiniceps*, *Edriolychnus schmidti* and *Ceratias holboelli*. "They have a general resemblance to the females in form, but differ from them in the development of structures for attachment, in the absence of the illicium (and of other rays in the spinous dorsal when these are developed in the female), the reduction or absence of spines on the head, the absence of teeth and the vestigial condition of the gut. The only organ of importance in the abdominal cavity is the large testis".

The attachment is so intimate that it is apparently impossible to decide where one fish begins and the other ends. It seems certain, likewise, that the blood systems of the two are continuous and that the male is fed by the female.

Here, therefore, are a group of facts which seem to require some explanation. Mr. Tate Regan makes the following pronouncement on this problem. "The reason why the Ceratioids, alone amongst Vertebrates, have males of this kind is evident. They are necessarily few in numbers in comparison with the more active fishes on which they prey, and they lead a solitary life, floating about in the darkness of the middle depths of the ocean. In such circumstances it would be very difficult for a mature fish to find a mate, but this difficulty appears to some extent to have been got over by the males, soon after they are hatched, when they are relatively numerous, attaching themselves to the females, if they are fortunate enough to meet them, and remaining attached throughout life. In all probability the males are incapable of free development and it is likely that the great majority of them fail to find a female and perish, although another possibility has been suggested to me, namely, that the post-larval fish that find and become attached to females develop into males and those that do not into females".

This explanation hardly seems to be more than a description, nor does it appear that Mr. Tate Regan is entirely satisfied with it. The problem is less superficial. Perhaps further specimens and further investigation may suggest a reason why the Ceratioids first found themselves in the poetic darkness of the middle depths, and how long it took them to devise this means for combatting with difficulties to which a more prudent but

doubtless less courageous intelligence would have applied the old adage "solvitur ambulando", in other words by mere evasion.

The introduction of chromosomes or hormones in explanation Mr. Tate Regan regards as a work of supererogation, and unlikely to elucidate the problem. G. W. Harris.

R. Rallier du Baty. "La Pêche sur les Bancs de Terre-Neuve et autour des Iles de St. Pierre et Miquelon". Office Scientifique et Technique des Pêches Maritimes. Mémoires (Série Spéciale), No. 5. Paris, 1926.

This memoir is evidently intended to appeal to both lay and scientific publics. The fascination of the lucid and vigorous style in which it is written, and the continual revelation it affords of the insight, sagacity and humanity of its author should cause it to receive a wider publicity than fishery papers usually attain. It has the dual aim of giving a comprehensive account of the topography and the fisheries and of explaining the observed facts on a scientific basis. In the former it is, surely, completely successful — at any rate so far as French participation is concerned.

The measure of success achieved in the latter is more difficult to assess. From the nature of the case one would not expect success. The region has never been fully surveyed biologically; there have certainly been less than a dozen hydrological voyages there. Biologists, consequently, will find themselves frequently at variance with Captain du Baty's interpretations, since these must be largely the outcome of personal opinion. Hydrologists will welcome the temperature data, which are an important addition to a scanty stock. Their attention should certainly be drawn to two records of a temperature of —3° at 50 m. and 100 m. in June (apparently referred to on p. 32 as occurring in July); this is surprising in this area since one would expect freezing to take place at about —2°.

Captain du Baty has added 16 useful and appropriate names to the chart of the region. His essay on bait is very interesting.

More particular reference to his authorities, with a bibliography, an index, and precise systematic nomenclature of the fauna would have added to the value of the memoir. For example *Pollachius virens*, with no authority, is given as the name of a common fish the Americans, he tells us, call both pollack and coalfish. Half a dozen baits are described only under their French names, among them the all important squid. Some of these which I took in Conception Bay in 1922 were *Illex illecebrosus* (Lesueur). Above all perhaps we would like to know the identity of that surprising animal — "la puce de mer, sorte d'euphausis qui pullule sur certains fonds. En pareil nombre il leur suffit de peu de temps pour manger jusqu'à l'arrête les morues prises aux lignes". Michael Graham.

Jean le Gall. La Pêche en Norvège. Office Scientifique et Technique des Pêches Maritimes. Mémoires, (Série spéciale), No. 4. Paris 1925.

Under this rather sweeping title M. le Gall records observations and information obtained during a visit to Norway in the spring of 1925. The title must not be understood too literally, in fact nobody with even

a superficial knowledge of Norway and its third industry would expect a full and detailed description of Norwegian fisheries. Fishing in Norway dates from the Stone Age and has subsequently developed in many different ways, influenced by historical events and the technical progress of every age, and intimately interwoven with the life of the people along the extended coast and with the other industries and occupations pursued in the country. It would consequently take a lifetime of study to accomplish such a task and that is the reason why no such work of a really comprehensive and authoritative character exists, and is not very likely to be forthcoming.

In the preface the author, however, states as his main task, laid upon him by the owners of herring drifters in the town of Boulogne, to investigate the North Sea herring fishery as pursued from Norway (where it is of very little importance despite the very thorough trial fisheries undertaken by the Norwegian Government a few years ago). This primary task is well fulfilled, the description of the nets and other gear detailed and as far as can be gathered, accurate. His description of the habitual methods of catching herring in Norway is also very good, especially the chapter devoted to the purse seine.

One might think it has been the author's purpose to improve upon Prof. GRUVEL, who wrote a book on the same subject only 3 years earlier (A. GRUVEL: En Norvège, Notes et Mémoires of the Office Scientifique et Technique, No. 15, Paris 1922).

The shortcomings of the work are however the same as those of its predecessor, undue generalisation and many inaccuracies. The charts, though very clear, contain too many faults to go into them all. As examples it is sufficient to mention that the adult saithe is represented as not occuring in N. Norway although the most prominent feature in the biology of this fish is that it lives in the north in summer and autumn to feed, going south every winter to spawn. The mackerel is represented as not being fished for on the east side of the Oslo fjord, where as a matter of fact a great proportion of the catch is taken. The figures of the food fish taken in Norway are of an indifferent nature. Those of the herring and sprat have changed place. The views reproduced bear no indications of locality or date. In the chapter on the curing of fish and roe, the photos illustrating the salt being washed out of the salt fish before drying it to klipfish, are given as "preparation of stockfish". The photo p. 35 purporting to show a fleet of fishing boats in a Lofoten port, shows really a number of smacks (jakt-s) employed for the purchasing of cod destined to be made into klipfish. The treatment of place-names shows that the author has not given much thought to such trifles as spelling.

Coming to expressions of opinion, there is one which better than any other shows the very superficial acquaintance of the author with his subject. He explains the reason for the absence of a trawl-fishery in Norway to be inter alia: "the mentality of the Norwegian fisherman who dislikes to venture far out to sea, and the fancy of the Norwegian public which is accustomed to very fresh fish." The first of these statements is contrary to fact, considering the hundreds of small steamers and cutters which work their lines very far out to sea on the continental edge all summer

and autumn, from the Faroes and Iceland to far into the Barents Sea, the field of operation being in later years extended even to the West Greenland banks; from which it may be assumed that the mentality of the Norwegian fishermen is so far sound, however it may fall short in other directions. The second statement is equally far from the point. There is undoubtedly good fresh fish to be had in Norwegian towns at most times, but salt, smoked and dried fish are also consumed in considerable quantities, being cheap and convenient; the home consumption is however in any case of slight importance, since about 80—90 per cent. of the fish landed in Norway has to be exported. And this is the real reason why trawling has so far not been adopted in Norway: a trawler would have to have a market for the fish, and Norway with her small and scattered population and long distances is no market for fresh fish. The fish landed in Norway has, broadly speaking, to be prepared for long keeping and long transport, and must consequently be cheap. But as to cheap fishing methods, the Norwegian methods are certainly superior to trawling, all things considered, and, what is also essential, do not reduce the men to mere "hands", a condition to which the mentality aforementioned is very much opposed.

The book contains useful accounts of the preparation of salted cod roe (for sardine bait), of salt mackerel and of the methods of capturing tunny, a new venture in Norway.

In short, the actual information for the sake of which this memoir was written, would advantageously have been set in a more modest frame.

Oscar Sund.

R. Spärck. Studies on the Biology of the Oyster (*Ostrea edulis*) in the Limfjord with special reference to the Influence of Temperature on the Sex Change. Rep. Danish Biolog. Stat., Vol. XXX. 1925.

Although the native oyster has been the subject of extensive research, especially with reference to its mode of reproduction and development, so that the hermaphrodite condition was discovered by Davaine as early as the fifties of the last century, yet it is only in the last few years that the facts of sex change have been definitely established by Spärck and Orton. It is interesting that they confirm and extend the original statements of Davaine and controvert those of Lacaze-Duthiers who, while he agreed that *Ostrea edulis* was hermaphrodite, denied that there was ever any change of sex, the different sexual conditions being permanent and due to the unequal development of the two kinds of sex cells. Spärck, in his detailed and authoritative paper, reviews fully the literature and attributes the slow acceptance of the facts of sexual alternation to the great influence of Lacaze-Duthiers.

Dr. Spärck's research is based on the microscopic examination of 1400 oysters from the Limfjord and the macroscopic examination of many more. It was unfortunate that in the years 1919—1921 when he did this work there was very little spat, so that he was only able to examine ten individuals less than one year old. Though these had in all cases male gonads, there was no ripe sperm and this he never found in oysters before the second summer, which he attributes to the low temperature, since

further south young oysters may produce ripe sperm in the year they are born. After the shedding of the sperm, the gonad begins to produce eggs and SPÄRCK was able to follow this process by boring holes through the shell and removing samples of the gonad contents from time to time with a pipette. He found the change-over to be very slow; practically all the time the eggs were being developed there was a continued, though gradually decreasing, spermatogenesis. The smallest oyster found with fry measured 6.5 cm. across and was two or possibly three years old; the majority of oysters in the Limfjord probably do not spawn till they are three years old. Immediately after spawning, the gonad begins to produce sperm again; this process is very rapid (as ORTON also has observed), thus an oyster which was white sick on the 17th of June and black sick on the 22nd was functioning as a male on the 8th of July.

The high percentage of males as contrasted with females has been noted by many workers and SPÄRCK now accounts for this by showing that, whereas the male stage (or stage when the sperm predominate in the gonad) may last in the Limfjord for from two to four years, the female stage (when the gonad is filled exclusively with eggs) may last only as many weeks, though if the ova are developed late they may be retained over the winter and shed in the following year when the temperature rises sufficiently.

The effect of temperature is fundamental. SPÄRCK, though he considers that egg development practically ceases at 10°—12° C. yet thinks that there is not a definite temperature below which oysters cannot spawn, but that the more slowly the temperature rises in any year the later in the year and the lower the temperature at which larvae are produced, thus in 1921 oysters were found with larvae at 13°—14° C., but in 1923 not till 16°—17° C. If, as in the Norwegian oyster pools, the temperature rises very high then the effect of temperature may be counterbalanced by the lack of sufficient food to cope with the increased demands of the animals. The larvae also are largely at the mercy of temperature; the higher it is, within limits, the faster they develop, the shorter the pelagic stage and so the greater the chance of their settling.

Since 1852, there have been two periods of maximum production in the Limfjord, in 1871—74 when 7 millions were taken annually and in 1915—16 when $5^1/_2$ million were dredged. Unfortunately, no temperature records exist for the earlier period, but the second maximum is clearly correlated with the high sea temperature — 20° C. or slightly above — in 1910—12 and 1914. An isolated hot summer, such as that of 1917, produced no increase because, according to SPÄRCK, the majority of ova produced in a hot summer are retained till the following year and if that is cold the increased spawning is discounted by the destruction of larvae. Under the conditions in the Limfjord, therefore, at least two consecutive hot years are necessary if there is to be a notable increase.

The oyster fishery has declined steadily since 1918 owing to the succession of cold summers between 1919 and 1922, when the temperature rarely reached 18° C. The distribution of *Ostrea edulis* shows that it is found within definite limits of temperature (and of salinity); though it can live in low temperatures it will, according to SPÄRCK, spawn so in-

frequently — at most once and perhaps never — that the stock cannot be maintained.

The paper concludes with a short discussion of the theoretical importance of alternating hermaphroditism, and some general observations on different aspects of the biology of the oyster — too diverse to be here discussed.

While perhaps it is to be wished that Dr. SPÄRCK had been able to obtain more abundant material, especially of young oysters, yet his work, together with that of ORTON, proves quite conclusively that *Ostrea edulis* is a protandric alternating hermaphrodite, and that, though salinity and nutrition must not be disregarded, temperature is the most important factor controlling the rate of increase. Economically this is of the first importance; clearly the Danish beds where the oyster seldom becomes female before it is three or four years old cannot hope to vie in production with the French beds where it becomes female after one year. The same drawback applies, though to a less degree, to British beds. It appears that, whereas the development of the French oyster industry has followed from improved methods of spat collection and of nutrition (in the "claires"), a similar development of the northern beds will only come after an equally effective solution of the temperature problem. This may not be insuperable since, when the right conditions have been experimentally determined, there seems no reason why enough spat should not be produced in artificially heated tanks to maintain, when added to the natural increase on the beds, a stock of oysters sufficient to supply the increasing modern demand.

C. M. YONGE.

J. N. CARRUTHERS. M. Sc. The water movements in the Southern North Sea. Part II. Bottom currents. — Fishery Investigations. Series II. Vol. IX. No. 3. 1926.

C'est la 2ème partie du rapport sur les recherches très étendues entreprises par le Ministère de l'Agriculture et des Pêcheries d'Angleterre. J. N. CARRUTHERS y rend compte des expériences instituées dans le but de déterminer les allures de ce qu'on peut appeler "la Dérive de fond", c'est-à-dire du cheminement des objets flottant au voisinage du fond. On se rapelle que la 1ère partie concernait la Dérive de surface, qui est directement et parfois puissamment influencée par le vent. La Dérive de fond échappe, au contraire, à l'action éolienne directe, elle est l'effet des courants alternatifs créés par le choc de l'onde de marée venue de l'Atlantique sur le talus continental puis par le jeu de ces courants entre les hauts-fonds et contre les côtes, à l'intérieur de la Mer du Nord.

L'auteur fait remarquer que, si la connaissance des allures de la Dérive de surface est d'une importance dominante parceque les œufs de tous les poissons alimentaires, sauf le hareng, flottent dans les eaux superficielles, celle de la Dérive de fond présente cependant, outre son intérêt océanographique, une grande importance biologique, parceque les jeunes larves du hareng, écloses près du fond, restent pendant quelque temps à la merci des courants de fond. En outre, d'après FULTON, les poissons de fond, comme la plie, au moment du frayage, nagent contre les courants,

et d'ailleurs, si les œufs des poissons démersaux sont plus abondants près de la surface, leurs larves et leurs premières post-larves s'accumulent dans les eaux intermédiaires et même au voisinage du fond. Il y a donc de multiples raisons de désirer que l'allure générale du mouvement des eaux de fond soit déterminée dans toutes les régions de notre mer. Mais la technique de ces recherches est encore plus délicate que celle des expériences sur la Dérive de surface, et l'interprétation des résultats est encore plus hérissée de difficultés.

L'expérience anglaise est la plus importante qui ait été entreprise jusqu'ici. Elle comprend la libération de 9525 flotteurs spéciaux, mis à flot par lots hebdomadaires de 25 pièces, en 7 stations fixes: les bateaux-phare Smiths-Knoll, Outer Dowsing, Swarte Bank, South Doggerbank, Galloper, North Hinder et Sandettie.

Les flotteurs de fond employés sont du type imaginé par Bidder: des bouteilles à soda, vides, bien scellées et contenant une carte-questionnaire à réexpédier après trouvaille. Ces flotteurs, comme pour la Dérive de surface, sont lestés pour surnager en émergeant très peu, mais un fil de cuivre dont le poids les fait, au contraire, sombrer, est fixé à leur goulot. Quand ce fil, étendu et rectiligne, arrive à toucher le fond, il fonctionne comme un guide-rope: la bouteille se trouvant allégée d'un certain poids, tend aussitôt à monter, mais son ascension s'arrête dès que la somme des poids du fil soulevé et du flotteur devient égale au poids du volume d'eau saline déplacé. La bouteille se maintient alors à une certaine hauteur au dessus du fond, mais est emportée dans le mouvement horizontal de l'eau qui la porte, parceque son guide-rope n'oppose guère de résistance.

On ne compte guère que sur le filet traînant des pêcheurs pour récupérer les flotteurs ainsi conditionnés. Cependant, en fait, on a ramassé un assez grand nombre de bouteilles échouées sur les plages. Les cas de ce genre sont de nature à attirer l'attention sur les conditions du cheminement des eaux de fond dans les régions où s'élèvent des séries de hauts-fonds tels que les bancs de sable du Sud de la Mer du Nord. Supposons, en effet, qu'il y ait en un point de cette région une eau de fond d'une salinité et d'une température données, charriant des larves de hareng, des formes jeunes de poissons démersaux, des larves de crustacés et d'autres formes benthiques, et qu'on y laisse tomber des flotteurs à fil équilibreur. Entraînée par un courant cette eau pourra heurter un de ces bancs et s'élever sur son talus en suivant le fond et en refoulant, dans cette ascension, les eaux de surface. Dépassant la crête de la saillie, une partie de la masse s'étalera au dessus des eaux de fond qui, de l'autre côté du banc, sont abritées contre le courant. On trouvera alors en cet endroit une couche horizontale formée d'une eau de fond devenue superficielle et continuant à charrier des corps flottants libres venus du fond de la localité initiale. Mais les flotteurs de fond, qui ne sont pas libres mais rattachés au sol par leur fil équilibreur, descendront, peut-être, sur la berge opposée et s'y trouveront plongés dans une eau de fond distincte de celle de leur région d'origine, charriant d'autres corps libres et subissant un déplacement différent. Dans cette hypothèse les flotteurs de fond n'indiqueraient plus

correctement le cheminement des corps flottants, œufs, larves etc. qui existaient au point d'immersion.

D'autre part, au lieu de rencontrer un banc, cette eau pourra heurter sous un certain angle une plage inclinée et s'y élever plus ou moins, tout en rasant l'estran et en continuant à charrier ses flotteurs de fond. Dès lors, ceux-ci pourront devenir le jouet d'une eau de surface, et aussitôt qu'ils atteindront un endroit où la profondeur est moindre que leur hauteur verticale au dessus du fond, ils émergeront et deviendront flotteurs de surface, soumis à l'action directe des vents. Ils ne tarderont pas à échouer sur une plage, à moins qu'ils ne se brisent sur des galets.

Bien d'autres causes de perte ou d'erreur sont signalées par CARRUTHERS: l'usure du fil sur le sable ou sa rupture causant le passage des bouteilles à l'état de flotteurs de surface, l'accrochage sur des fonds pierreux, couverts de polypes ou de bryozoaires, le développement d'organismes fixes, moules, balanes etc., et enfin l'indication défectueuse des localités de trouvaille. Il examine tous les cas possibles de perturbation de l'expérience, indique l'usage qui peut être fait des récaptures obtenues autrement que par la pêche en mer, fait un examen critique des résultats de ses prédécesseurs BIDDER, BROWN, JEE, ROOSENDAAL, WIND et VAN EVERDINGEN, et conduit avec un grand souci d'exactitude l'ensemble de la laborieuse étude des faits recueillis.

Nous ne pouvons le suivre dans l'analyse détaillée des résultats fournis par les sept bateaux-phare, ce serait répéter tout son travail. Disons cependant que l'investigateur engagé dans l'étude du mouvement des eaux dans notre mer ne peut s'abstenir de lire et de méditer les exposés synthétiques donnés séparément par CARRUTHERS pour chacun de ces sept points de départ. Il y acquerrera, outre la connaissance des faits, la notion de la complexité des causes qui entraînent la variabilité des résultats.

L'allure générale des mouvements des eaux de fond, dans toute l'étendue de la Mer du Nord, ne peut pas plus que celle des eaux de surface, s'exprimer en une formule simple. Trop de facteurs y interviennent, constamment ou périodiquement. Cependant la complexité des résultats ne détourne pas CARRUTHERS de tenter d'en exprimer l'allure sous une forme très généralisée et intuitive, dans ses cartes IX, X, et XI. La dernière (chart XI, p. 111) expose sous la forme la plus généralisée, ce que l'ensemble des observations permet aujourd'hui de considérer comme le régime le plus normal des déplacements de l'eau de fond dans le Sud de la Mer du Nord, tout en faisant la part de la possibilité des variations, saisonnières et annuelles, de direction et de vitesse.

Il est fort intéressant d'y voir que l'eau de la Manche entrée par le détroit s'étale en éventail en marchant vers la partie Nord, avec une prédominance de marche vers le N.E. le long de la côte continentale, puis qu'au Nord du 53ème degré de latitude il s'établit un grand tourbillon cyclonique (peut-être parfois réversé).

Sans doute les recherches de l'avenir permettront de perfectionner cette carte, en introduisant de nouvelles valeurs dans l'établissement des directions et des vitesses moyennes. Peut-être sera-t-il possible un jour de montrer sur une même carte, à la fois le régime moyen de la circulation profonde, la plus constante, et celui de la circulation superficielle,

plus changeante, en vue d'obtenir une carte-base sur laquelle on pointerait périodiquement les variations saisonnières ou extraordinaires. Mais, dans son état actuel la carte de CARRUTHERS sera déjà d'un grand secours à ceux qui cherchent à coordonner les observations parallèles de salinité, de température et de plancton faites au cours d'une période donnée. Elle servira peut-être à faire accepter la notion de la nécessité d'un service permanent international de surveillance de la Mer du Nord, comprenant non seulement des observations de bateaux-phare, mais aussi l'exécution de sections hydrographiques complètes, avec jet de flotteurs de fond et de surface, sur des lignes bien choisies. Parmi celles-ci les sections GRISNEZ-SHAKESPEARE CLIFFS, ZEEBRUGES-ORFORDNESS et HELDER-CROMER, paraissent maintenant s'imposer pour la partie Sud, — le choix de celles de la partie Nord demandant encore des précisions préalables. L'Océanographie pure n'est pas seule à réclamer ces observations suivies: elles sont très nécessaires aux études de Pêcheries et de Météorologie, branches appliquées dont l'importance n'échappe plus même aux mentalités les plus étroitement utilitaires. La prise en considération de ces désiderata sera peut-être un des plus heureux effets du grand effort réalisé par le Ministère de l'Agriculture et des Pêcheries d'Angleterre et dont CARRUTHERS vient d'exposer, avec tant de maîtrise, les principaux résultats.

GILSON.

H. J. BUCHANAN-WOLLASTON. Plaice-Egg Production in 1920—21, treated as a statistical Problem, with Comparison between the Data from 1911, 1914 and 1921. — Fishery Investigations Ser. II. Vol. IX. No. 2. London 1926.

Die Arbeit behandelt das Laichen der Scholle in den Hoofden (Flemish Bight). Es sei zuvor daran erinnert, dass die grosse Bedeutung dieses Laichplatzes schon im ersten Jahrzehnt dieses Jahrhunderts bekannt geworden ist durch mehrere Veröffentlichungen zuerst holländischer, dann auch deutscher Untersuchungen; dabei konnten dank der Hensen'schen quantitativen Methode bereits recht genaue Angaben gemacht werden z. B. über Lage und Umfang des Laichplatzes und dessen Kern am Ostrande der "Tiefen Rinne" in der Region des wärmsten und salzigsten Wassers, sowie über die Dauer der Laichzeit, die im Dezember im Süden des Laichplatzes beginnt, im Januar auf der Höhe ist und Anfang März zu Ende geht.

Diese allgemeinen Erscheinungen fanden Bestätigung durch die englischen Untersuchungen, die in der Laichperiode 1910—11 unter Leitung von BUCHANAN-WOLLASTON in sehr gründlicher Weise aufgenommen wurden. Während bei den früheren Untersuchungen das Gebiet nur auf vereinzelten Fahrten verschiedener Jahre an verhältnismässig wenigen Stationen besucht werden konnte, bedeckte BUCHANAN-WOLLASTON auf mehreren Fahrten während der Haupt-Laichzeit das ganze in Frage kommende Areal gleichmässig mit zahlreichen Stationen, und zwar in den 3 Laichperioden 1910—11, 1913—14 und 1920—21. Die Berichte über die beiden ersten befinden sich in Fishery Investigations Ser. II, Vol. II, No. 4, 1915,

bezw. Vol. V, No. 2, 1923; die letzte betrifft die in der Überschrift genannte Abhandlung. Alle drei Arbeiten müssen im Zusammenhange studiert werden.

Besonders hervorzuheben ist das erfolgreiche Streben nach Vervollkommnung der Methodik sowohl des Fanges selbst als auch besonders der Auswertung und Darstellung der Befunde. Die Fangmethode mit dem Hensen-Netz wurde verbessert durch Einführung der Gegengewicht-Methode, wobei das fischende Netz durch ein sinkendes Gewicht aufgeholt wird zur Vermeidung von Fehlern, die z. B. infolge von Ungleichmässigkeiten des Netzzuges durch Überholen des Schiffes bei schlechtem Wetter oder durch die Bedienungs-Mannschaft oder durch Verstopfung des Netzes entstehen. Der Laichplatz erwies sich als ein in sich abgeschlossenes Gebiet, so dass das Vorkommen der Eimengen durch geschlossene Umriss-Linien dargestellt werden kann, ausserhalb welcher nur so wenige Eier vorhanden sind, dass sie bei Berechnungen als unwesentlich ausser Acht gelassen werden konnten. Damit war es möglich, die Eimenge hier als eine einheitliche, messbare Quantität zu behandeln und die jährliche Produktion zu berechnen, die — wie schon Hensen gesagt hat — das zuverlässigste Kriterium der Grösse des Fischbestandes ist, der sie hervorbringt, und das am leichtesten erreichbare. Wesentliche Unterschiede in der Grösse der jährlichen Eiproduktion können hier mit einem hohen Mass von Sicherheit festgestellt werden zur Klärung der für wissenschaftliche und praktische Zwecke so überaus wichtigen Frage guter und schlechter Laichjahre und zum Vergleich mit den Fischerei-Ergebnissen in den folgenden Jahren.

Zur Erreichung einer recht vollkommenen Vergleichsmöglichkeit zwischen dem zu verschiedenen Zeiten gewonnenen Tatsachen-Material hat Buchanan-Wollaston auf die statistische Verarbeitung das Hauptgewicht gelegt und — ganz im Hensen'schen Sinne — möglichst exakte mathematische Berechnungs- und Darstellungsweisen benutzt bezw. neu erdacht und immer weiter vervollkommnet, die anhangsweise eingehend dargestellt wurden. Diese gründliche Behandlungsweise ist ein grosser Fortschritt, und es muss hervorgehoben werden, dass die Methoden auch für andere Zwecke geeignet sind und daher allgemeine Beachtung verdienen. Für die vorliegenden Untersuchungen dienten die Methoden hauptsächlich zur Berechnung folgender Aufgaben:

1. Umrisslinien für die Regionen bestimmter Eizahlen (junge und alte Eier) pro qm Oberfläche in den verschiedenen Phasen der Laichzeit.
2. Ei-Produktion (Laichintensität, Veränderung derselben im Laufe der Laichzeit, Gesamtproduktion).
3. Feststellung der Lage der Laichzentren.
4. Drift der die Eier enthaltenden Wassermassen.
5. Sterblichkeit der Eier während der Entwicklungszeit.

Zur Hoch-Zeit (etwa Mitte Januar) herrschte alle drei Jahre enge Übereinstimmung in der Position des Laichgebiets, ebenso auch in der Figur der Umrisslinien; weniger Übereinstimmung bestand in der späteren Laichzeit. Mit fortschreitender Jahreszeit bewegt sich der Laichplatz nord- und ostwärts; in allen drei Jahren stimmt diese Bewegung recht

eng mit der Bewegung des starksalzigen und warmen Wassers überein. Der Laichplatz lässt meist zwei Teile erkennen, die durch eine Barre in der "Tiefen Rinne" auf der Breite von Southwold getrennt sind; das seichtere Wasser darüber ist oft weniger warm und salzhaltig. Für 1914, das sich nach dem 2. Bericht bei Anwesenheit einer viel grösseren Menge stark salzigen Wassers in den Hoofden als bedeutend besseres Laichjahr als 1911 erwies, wurde folgende Ei-Produktion berechnet: Januar im Laichzentrum ca. 48 Eier pro qm. in 3 Tagen, Februar desgl. im südlichen Zentrum 36, im nördlichen 39 pro qm. Anzahl der im ganzen Gebiet in 3 Tagen produzierten Eier: Januar annähernd 180,000 Millionen, Februar 157,000 Millionen. Monatliche Produktion rund 2,000,000 Millionen, Totalproduktion des Jahres vermutlich wenigstens 5,000,000 Millionen Stück. Um diese Menge hervorzubringen, müssen etwa 20 Millionen weibliche Schollen und wenigstens ebenso viele Männchen auf diesem Grunde gelaicht haben.

1921 war die Eiproduktion nahezu zweimal so gross als 1914, auch hatte das Verbreitungsgebiet der Eier eine viel grössere Ausdehnung. Im Vergleich zum schlechten Laichjahr 1911 war die Produktion von 1921 drei bis viermal so gross. Dies wichtigste Ergebnis von allgemeinem Interesse steht also im Einklang mit den übrigen Feststellungen über die Vergrösserung des Schollenbestandes in der Nordsee nach dem Kriege, auch mit den deutschen Befunden über die Eimengen in der Laichperiode 1919—20.

Aus Reife- und Geschlechtsbestimmungen getrawlter Schollen geht hervor, dass sie den Laichgründen entlang der Ostseite der "Tiefen Rinne" zustreben und sie auf der Westseite verlassen, wo entlang der englischen Küste eine südlich gerichtete Strömung streicht, so dass die Laichwanderung gegen den Strom geht. Wie schon früher beobachtet, waren die Fänge auf den Laichgründen durch eine grosse Zahl von fliessenden Männchen charakterisiert, während sich die Weibchen hier mit dem Trawl nicht fangen lassen, nach Ansicht von Buchanan-Wollaston wahrscheinlich wegen der Geschwindigkeit, mit der sie ihren Laich abgeben.

Die Verteilung der Eier nach der Ablage wurde gewöhnlich recht gleichmässig in allen Wassertiefen und nicht an der Oberfläche angesammelt gefunden. Während der Entwicklung breiten sich die Eier über ein grösser werdendes Gebiet aus, ein Teil wird mit der Oberflächenströmung fortgetrieben, andre bleiben zurück und folgen langsam in tieferen Lagen, andere können vielleicht in entgegengesetzte Richtungen vertrieben werden. Es scheint eine linksdrehende Wirbelbewegung in der Mittelschicht vorhanden zu sein, welche die Eier nördlich in das tiefe Wasser gegenüber von Lowestoft zu versetzen strebt. Das zum Laichen gewählte möglichst starksalzige und warme Wasser kann an Stellen vorkommen, die für das Fortkommen der Brut ungeeignet erscheinen; ein grosser Teil der Eier kann trotz einer günstigen Oberflächen-Drift unterhalb derselben in vielleicht sehr ungünstige Gegenden vertrieben werden. (Diese Verhältnisse sollen aufgeklärt werden durch Untersuchung der schlecht bekannten Verbreitung der postlarvalen und ersten Bodenstadien.)

Die allgemeine Drift der Eier über dem Laichplatz — abgesehen natürlich von dem Hin und Her der Tide — konnte Buchanan-Wollaston nach

Richtung und Schnelligkeit berechnen, indem er Schwerpunktszentren bestimmte für die Verbreitungsgebiete der zu einer gewissen Zeit abgelegten Eier in ihren allerersten Entwicklungsstadien und derselben Eier in den Stadien kurz vor dem Ausschlüpfen (Zeitraum von ca. 2 Wochen unter Berücksichtigung der Entwicklungsdauer nach Tagesgraden n. Apstein). Die Entfernung zwischen den beiden Schwerpunktszentren ergibt die Drift, die in allen untersuchten Fällen nordöstlich gerichtet war und in 12 Tagen zwischen 18 und 37 Meilen betrug. Eine Messung der Bewegung der gesamten Wassermasse mittels der Fischeier, die mit Millionen von Treibflaschen nicht vollendeter erreicht werden könnte!

Die Verfrachtung der Eier geschieht also ziemlich langsam. Schon im 1. Bericht gelangte Buchanan-Wollaston zu der Vorstellung einer nur schwachen restlichen Drift nach Norden, da die grössten Larven-Zahlen in der Regel mit den grössten Eier-Zahlen zugleich gefunden werden, dabei aber mehr Larven vorkommen nordwärts als südwärts vom Laichzentrum. Falls die Annahme richtig ist, dass dieser Laichplatz die südöstlichen Küsten der Nordsee mit Jungschollen versorgt, so muss jedenfalls der grösste Teil der Reise von den jungen Fischen nach Vollendung ihres pelagischen Lebens gemacht werden.

Die Sterblichkeit der Eier während ihrer Entwicklung ist hoch; nach den Berechnungen des 2. Berichts gelangen wahrscheinlich nur 10—30 % der Eier zum Ausschlüpfen.

Zum Schluss möchte der Referent die Ausführungen am Ende des 2. Berichtes über die Bedeutung der quantitativen Eier-Untersuchungen für praktische Fischereiaufgaben unterstreichen und die regelmässige Fortsetzung dieser Beobachtungen dringend empfehlen, ausserdem ihre Erweiterung auf die übrigen Laichplätze der Nordsee – zwecks Vergleichbarkeit überall nach den gleichen Fangmethoden! M.

Correspondence.

To the Editor of the "Journal du Conseil":—

Wanted: an Atlas of the more important fish-food animals.

Everybody working on the distribution of plankton animals or bottom grab material from the viewpoint of fish-food must have realised the difficulties arising from want of adequate descriptions and figures of even the commonest fish-food animals and their developmental stages, and it is to be expected that this state of things will continue for a long time to come if proper steps are not taken by the authority most likely to show an interest in the matter, the International Council, which has besides already shown the way in publishing some years ago a very handy review of the more important fish eggs. The Council's lists of fish names (Publ. de Circ. No. 12) and of plankton organisms (Publ. de Circ. Nos. 33, 48 and 70) are instances of a similar nature. But there remains the lack of a handy handbook or atlas giving figures and descriptions on uniform lines of the principal fish-food animals. If restricted to the forms of real importance its scope would not be so very far-reaching, as, I believe, only about a score or so of plankton species and as many bottom animals can be said to be very important. Of course a part of the work has already been done, and this would only have to be properly arranged for the end in view. But many of these forms are imperfectly known as to development, and this would have to be made good by cooperation. I believe this could be done in a few years if the Council set up a small Committee, or a single Editor for the purpose, to encourage the workers in the different countries to investigate the species most likely to come within their reach and to arrange and coordinate the results in handy form together with the material available in the literature already published.

Bergen, Dec. 1926. OSCAR SUND.

It is to be hoped that this suggestion will be considered by the Council. The pages of the Journal are available for the publication by instalments of such an Atlas.

EDITOR.

Current Bibliography.

Prepared by the Editor.

NOTE. The scope of the Bibliography is limited in the main to the area covered by the Council's activities, but there are included papers of general interest relating to other areas in the North Temperate and Arctic regions and exceptionally elsewhere. Limnological references are not as a rule given, but papers relating to brackish waters and to salmon and freshwater fish studied by the Council are included.

The classification of entries follows in a general way that adopted in Dr. ALLEN's Selected Bibliography published in Vol. I Nos. 1 and 2 of the Journål, and since reprinted.

Subscribers and those on the distribution list will receive regularly upon application to the General Secretary copies of the Bibliography printed on one side of the page only, for use in making up card indices.

The Editor will be glad to be advised of emendations and additions to the Bibliography.

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